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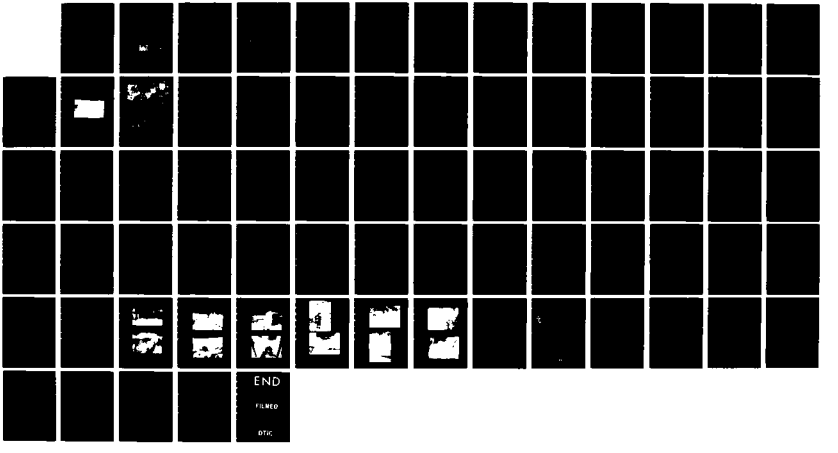
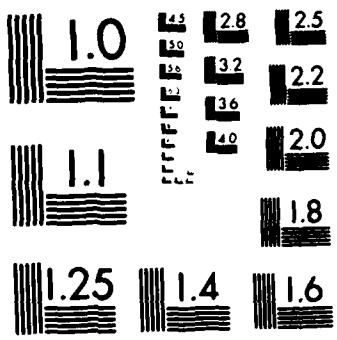




MASSACHUSETTS—RHODE ISLAND COASTAL BASIN

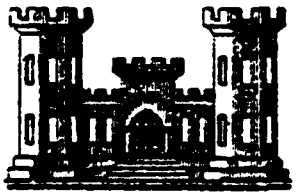
WINCHESTER, MASSACHUSETTS

NORTH RESERVOIR DAM

MA 00457

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM



DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASS. 02154

FEBRUARY 1979

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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Cover program reads: Phase I Inspection Report, National Dam Inspection Program; however, the official title of the program is: National Program for Inspection of Non-Federal Dams; use cover date for date of report.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

DAMS, INSPECTION, DAM SAFETY,

Massachusetts-Rhode Island Coastal Basin
Winchester, Massachusetts
Sawmill Brook

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

North Reservoir Dam is an earth embankment approximately 600 ft. long and 27 ft. high. An open channel spillway extends around the right abutment and a 19 ft. wide by 2 ft. high concrete weir is located at the spillway crest. The dam is fair condition, based on visual examination of the structure. It is considered to be small is size and high in hazard potential.

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REPLY TO
ATTENTION OF:

NEDED

APR 20 1979

Honorable Edward J. King
Governor of the Commonwealth of
Massachusetts
State House
Boston, Massachusetts 02133

Dear Governor King:

I am forwarding to you a copy of the North Reservoir Dam Phase I Inspection Report, which was prepared under the National Program for Inspection of Non-Federal Dams. This report is presented for your use and is based upon a visual inspection, a review of the past performance and a brief hydrological study of the dam. A brief assessment is included at the beginning of the report. I have approved the report and support the findings and recommendations described in Section 7 and ask that you keep me informed of the actions taken to implement them. This follow-up action is a vitally important part of this program.

A copy of this report has been forwarded to the Department of Environmental Qaultiy Engineering, the cooperating agency for the Commonwealth of Massachusetts. In addition, a copy of the report has also been furnished the owner, Town of Winchester, Public Works Department, 15 Lake Street, Winchester, Massachusetts 01890.

Copies of this report will be made available to the public, upon request, by this office under the Freedom of Information Act. In the case of this report the release date will be thirty days from the date of this letter.

I wish to take this opportunity to thank you and the Department of Environmental Quality Engineering for your cooperation in carrying out this program.

Sincerely yours,

JOHN P. CHANDLER
Colonel, Corps of Engineers
Division Engineer

Incl
As stated

MASSACHUSETTS-RHODE ISLAND COASTAL BASIN
WINCHESTER, MASSACHUSETTS

NORTH RESERVOIR DAM

MA 00457

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASS 02154

FEBRUARY 1979

PHASE I INVESTIGATION REPORT
NATIONAL DAM INSPECTION PROGRAM

Identification No.:	MA 00457
Name of Dam:	North Reservoir
Town:	Winchester
County:	Middlesex
State:	Massachusetts
Stream:	Sawmill Brook
Date of Site Visit:	6 December 1978

BRIEF ASSESSMENT

North Reservoir Dam is an earth embankment approximately 600 ft. long and 27 ft. high. The dam was completed in 1874 and is reported to be founded on ledge and to have a masonry core wall. An open channel spillway extends around the right abutment and a 19 ft. wide by 2 ft. high concrete weir is located at the spillway crest. Outlets consist of a 16-in. water supply line and a 30-in. blow-off pipe which is presently inoperative.

Due to the extent of downstream development that would be affected in the event the dam were to fail, North Reservoir Dam is confirmed as having a "high" hazard potential in the Corps of Engineers National Inventory of Dams.

The dam is in fair condition, based on a visual examination of the structure. Although some deficiencies were noted, there was no evidence of settlement, lateral movement or other signs of structural failure or other conditions which would warrant urgent remedial action.

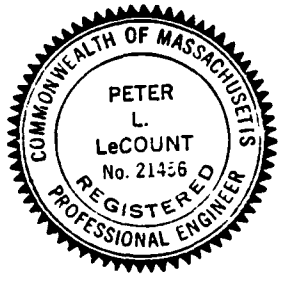
Based on the size (small) and hazard potential (high) classifications in accordance with the Corps of Engineers guidelines, the test flood for this dam is one-half the Probable Maximum Flood (1/2 PMF). With the water level at the top of the dam, the ungated spillway capacity is 450 cfs. Hydraulic analyses indicate that the test flood outflow of 175 cfs (inflow of 1,560 cfs or 2,700 csm) can be passed with a freeboard of about 1.7 ft. and with an unused surcharge-storage of 120 acre-ft. remaining.

The Town of Winchester, owner of the dam, should engage a registered professional engineer to conduct investigations including assessment of the seismic stability of the dam embankment and evaluation of the seepage condition below the embankment toe, as outlined

in Section 7.2. The results of those investigations and remedial measures including clearing the spillway channel and restoring the blow-off pipe to service, as outlined in Section 7.3, should be implemented by the owner within one year after receipt of this report. As also recommended, a program of biennial periodic technical inspections should be instituted.

HALEY & ALDRICH, INC.
by:

Peter L. LeCount
Vice President



PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the office of Chief of Engineers, Washington, DC 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I Investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that unsafe conditions be detected.

Phase I Investigations are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the test flood is based on the estimated "probable maximum flood" for the region (greatest reasonably possible storm run-off), or a fraction thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the test flood should not be interpreted as necessarily posing a highly inadequate condition. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential. Consideration of downstream flooding other than in the event of a dam failure is beyond the scope of this investigation.

The Phase I Investigation does not include an assessment of the need for fences, gates, no-trespassing signs, repairs to existing fences and railings and other items which may be needed to minimize trespass and provide greater security for the facility and safety to the public. An evaluation of the project for compliance with OSHA rules and regulations is also excluded.

TABLE OF CONTENTS

This Phase I Inspection Report on North Reservoir Dam has been reviewed by the undersigned Review Board members. In our opinion, the reported findings, conclusions, and recommendations are consistent with the Recommended Guidelines for Safety Inspection of Dams, and with good engineering judgment and practice, and is hereby submitted for approval.

Joseph A. McElroy

JOSEPH A. MCELROY, MEMBER
Foundation & Materials Branch
Engineering Division

Carney M. Terzian

CARNEY M. TERZIAN, MEMBER
Design Branch
Engineering Division

Joseph W. Finegan, Jr.

JOSEPH W. FINEGAN, JR., CHAIRMAN
Chief, Reservoir Control Center
Water Control Branch
Engineering Division

APPROVAL RECOMMENDED:

Joe B. Fryar

JOE B. FRYAR
Chief, Engineering Division

TABLE OF CONTENTS (Continued)

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

Routine operation of the dam consists of removing and cleaning the gatehouse intake screens and recording the reservoir level at the dam twice a week.

4.2 Maintenance of the Dam

There is no established maintenance program for the dam.

4.3 Maintenance of Operating Facility

Other than cleaning of the gatehouse intake screens, there is no established maintenance program for the operating facilities.

4.4 Description of any Warning System in Effect

There is no warning system or emergency preparedness plan in effect for this structure.

4.5 Evaluation

A biennial observation and maintenance program should be established to examine the dam, control tree and brush growth and maintain the spillway channel and weir. The 30-in. blow-off pipe should be made operative and operated periodically. A warning system or emergency preparedness plan should also be established.

be little probability that landslides into the reservoir would cause waves which would overtop the dam. No conditions which might result in a sudden increase in sediment load into the pond were noted.

e. Downstream Channel. The reservoir area was drained by Sawmill Brook before construction of the dam. The downstream channel of the spillway now joins old Sawmill Brook at a distance of about 300 ft. from the spillway. The brook continues westward to a point near Highland Avenue where it discharges into a steel conduit (approximately 2 ft. diameter). The conduit is believed to be connected to the municipal drainage system, through which, flow would eventually reach the Aberjona River, about 3,500 ft. from the dam site. It was not possible to observe the discharge route downstream of Highland Avenue.

A concrete arched culvert is located on the channel, underneath a service road, about 210 ft. downstream of the spillway. The channel gradient in this reach is quite steep, at about 8 percent. The stream bed is overgrown with dense vegetation and occasional large boulders were observed along the channel, Photos No. 10 and 11.

3.2 Evaluation

Based on the visual examination of 6 December 1978, the overall condition of the dam and appurtenant structures is considered to be fair. Deficiencies which have been noted should not effect the performance of the dam.

Photos No. 12 and 13. A slight upflow was noted in one of the pools but there was no evidence of soil movement. It was reported that a small building once covered the pools and that seepage was collected and pumped back to the reservoir. It was also reported that there have been problems with accumulation of seepage water in a pit inside the chlorination station.

c. Appurtenant Structures. The spillway weir is approximately 19 ft. long, 2 ft. high and is in fair condition. The concrete weir consists of two 8-ft. sections separated by a 3 ft. wide opening with stoplogs. The stoplogs are in a deteriorated condition. Remnants of sandbags were observed in the area behind the stoplogs. The 8 ft. long concrete sections are out of alignment, indicating some horizontal movement has taken place, Photo No. 8. Minor cracks, stains and spalling were observed. Seven 1-in. diameter steel pins, equally spaced, were embedded in the crest of the weir and could be used to support temporary flashboards. The spillway approach channel was in good condition, Photo No. 9.

The gatehouse is a mortared stone masonry and brick structure with a slate covered roof, Photo No. 6. A steel pedestrian bridge provides access to the gatehouse. The bridge appears to be well maintained and in good condition, but minor rusting is taking place. Copper flashing on the gatehouse roof is in need of repair.

There are three water supply intakes plus an intake noted as a reservoir drain. The three water supply intakes are operative, but the reservoir drain is reported to be silted up. Regardless of whether the drain is plugged or not, the drain has a 24-in. gate valve in the closed position at the gatehouse which is inoperative. In addition to the water transmission line leaving the gatehouse, there is a 30-in. blow-off pipe which is gated at the gatehouse end. The gate is in the closed position and is inoperative. The location of the outlet end of blow-off pipe is unknown. Therefore, at present, drainage of the reservoir can only be accomplished to the elevation of the lower intake, (El. 131.0), by flow through the 16-in. water supply line. The gate operators for the supply line and blow-off pipe are shown in Photo No. 7.

d. Reservoir Area. The area around North Reservoir is generally well preserved woodlands. There appears to

SECTION 3 - VISUAL EXAMINATION

3.1 Findings

a. General. The Phase I visual examination of the North Reservoir Dam was conducted on 6 December 1978.

In general, the project was found to be in fair condition. Some deficiencies which require correction were noted.

A visual inspection check list is included in Appendix A and selected photographs of the project are given in Appendix C. A "Site Plan Sketch", page C-1, shows the direction of view of each photograph.

b. Dam. The earth embankment is generally in good condition. There was no evidence of settlement, lateral movement or other serious defects. Slight seepage was evident, but is understood to be a long-standing condition.

The following specific items were noted:

1. The embankment crest has an earth and stone-dust roadway which shows slight wear by vehicle traffic, Photos No. 3 and 4.

2. The embankment slopes are mostly grass covered with some brush and small saplings, Photos No. 1, 3 and 4. Some localized erosion was noted on the upstream face near the crest.

3. Riprap consisting of 12 to 18-in. stones and present along the upstream face below approx. El. 147, is locally dislodged, Photos No. 2 and 3.

4. It is reported that animal burrows were found in the embankment in the past and that attempts were made to exterminate the animals. However, no evidence of animal burrows was noted during the site visit. The unmowed grass on the downstream slope impeded close examination.

5. Wet ground and local colorless seepage were noted along the base of the berm below the toe of the embankment. There is a small swampy area about 50-ft. further downstream with two concrete-walled pools,

SECTION 2 - ENGINEERING DATA

2.1 Design Data

No design data for the dam were located. A written description of the embankment is contained in the "History of Winchester, MA" by H.S. Chapman.

A drawing of the gatehouse, prepared in November 1943, was located at the office of the Town Engineer and a copy is included as page B-8.

2.2 Construction Records

No construction records were located.

2.3 Operation Data

There are no operation records other than reservoir elevations which are taken twice a week at the dam.

2.4 Evaluation

a. Availability. A list of engineering data available for use in preparing this report is included on page B-1. Selected documents from the list are also included in Appendix B.

b. Adequacy. There was a lack of engineering data available to aid in the evaluation of North Reservoir Dam. This Phase I assessment was therefore based primarily on visual examination, approximate hydraulic and hydrologic computations, consideration of past performance and application of engineering judgement.

c. Validity. There is no reason to doubt the validity of the available engineering data.

g. Dam Embankment

1.	Type	Earth
2.	Length	600 ft. (est.)
3.	Height	27 ft. (est.)
4.	Top width	13 ft.
5.	Side slopes	2H to 1V Downstream (approx.) 1.2H to 1V Upstream, Upper portion (approx.)
6.	Zoning	Unknown
7.	Impervious Core	Masonry wall
8.	Cutoff	Founded on bedrock
9.	Grout curtain	None
10.	Other	Riprap on upstream face below approx. El. 147

h. Diversion and Regulating Tunnel. Not applicable

i. Spillway

1.	Type	Open channel with 2 ft. high weir
2.	Length of weir	19 ft. at El. 147.3 (top of weir)
3.	Crest elevation	145.2 (channel bottom)
4.	Gates	None (stoplogs are a maximum of 2 ft. above channel bottom)
5.	U/S channel	4 percent slope toward reservoir (est.)
6.	D/S channel	8 percent (est.)

j. Regulating Outlets. There are four intakes and two outlets at the gatehouse, as shown on page B-8. Three arched inlet openings, with invert elevations of 131.0, 136.8 and 142.8, are controlled by moveable planks. A 24-in. reservoir drain pipe with an invert elevation of 120.8 is gated at its discharge end within the gatehouse. It is reported that the reservoir-bottom inlet for the drain pipe is silted up and that the gate is closed and inoperative.

A 16-in. water supply line connects the gatehouse to the chlorination station. The supply pipe is gated at both ends and has an invert elevation of 120.8 at the gatehouse. A 30-in. blow-off pipe with invert elevation of 120.8 at the gatehouse leads to an unknown outlet location. The blow-off pipe gate valve is reported to be closed and inoperative.

4. Ungated spillway capacity at test flood pool elevation..... 175 cfs at El. 149.0
5. Gated spillway capacity at normal pool elevation... Not applicable
6. Gated spillway capacity at test flood pool elevation..... Not applicable
7. Total spillway capacity at test flood pool elevation.. 175 cfs at El. 149.0
8. Total project discharge at test flood pool elevation.. 175 cfs at El. 149.0

c. Elevation (ft. above NGVD)

1. Streambed at centerline of dam..... 123.5 (estimated)
2. Maximum tailwater..... Unknown
3. Upstream portal invert diversion tunnel..... Not applicable
4. Normal pool..... 141.5 to 145.2
5. Full flood control pool..... Not applicable
6. Spillway crest (without stoplogs)..... 145.2 (estimated) (with stoplogs)..... 147.2 (estimated)
7. Design surcharge - original design..... Unknown
8. Top of dam..... 150.7
9. Test flood design surcharge.. 149.0

d. Reservoir

1. Length of maximum pool..... 0.8 mi. (Est.)
2. Length of recreation pool.... 0.7 mi. (Est.)
3. Length of flood control pool. Not applicable

e. Storage (acre-feet)

1. Normal pool..... 300 to 500
2. Flood control pool..... Not applicable
3. Spillway crest..... 500
4. Top of dam..... 860
5. Test flood pool..... 740

f. Reservoir Surface (acres)

1. Normal pool..... 50 to 60
2. Flood control pool..... Not applicable
3. Spillway crest..... 60
4. Test flood pool..... 70
5. Top of dam..... 80

The control weir in the spillway appears to have been added sometime after original construction. There have been no apparent structural changes to the original embankment or gatehouse.

i. Normal Operational Procedures. The control works are operated for water supply purposes. The 16-in. water supply line from the gatehouse to the chlorination station is usually open and flowing at all times. The reservoir drain and blow-off pipe are normally kept closed. Operational procedures consist of removing and cleaning the screens of the intake openings in the control structure twice a week. Reservoir water levels are recorded on those days. Additional routine maintenance is performed as required.

1.3 Pertinent Data

Some records for North Reservoir Dam show elevations referenced to the Town of Winchester Datum. Elevations in the text of this report are referenced to the National Geodetic Vertical Datum (NGVD), formerly referred to as Mean Sea Level Datum. To convert to the town datum, it is necessary to add 5.47 ft. to NGVD elevations.

a. Drainage Area. The drainage area of the North Reservoir Dam is approximately 370 acres (0.58 sq. mi.) and is located in the northwest corner of the Middlesex Fells. The watershed is separated from the adjacent basins by several hills. The majority of the area consists of well preserved woodlands. The normal surface area of the reservoir (about 50 acres) represents approximately 14 percent of the drainage area.

The Middle Reservoir of the Winchester Water Works is connected to the North Reservoir with a 10-in. diameter valved pipe for the purpose of supplementing the North Reservoir during prolonged droughts. The valve is normally closed and the drainage area tributary to the Middle Reservoir is not included in the above 370 acres.

b. Discharge at Dam Site

1.	Outlet Works.....	16-in. water supply line and 30-in. blow-off (inoperative)
2.	Maximum known reservoir elevation.....	146.8 on 13 April 1936
3.	Ungated spillway capacity at top of dam.....	450 cfs at El. 150.7

and sides of the spillway channel and low masonry training walls are present along some sections of the channel downstream of the weir. The channel joins old Sawmill Brook about 300 ft. downstream from the spillway weir.

c. Size Classification. The storage to the top of North Reservoir Dam is estimated to be 860 acre-ft., and the corresponding maximum height of the dam is approximately 27 ft. Storage of less than 1,000 acre-ft. and a height of less than 40 ft. classifies the dam in the "small" size category according to guidelines established by the Corps of Engineers.

d. Hazard Classification. The dam is currently classified as having a "high" hazard potential in the Corps of Engineers National Inventory of Dams. Dam failure analysis computations in Appendix D which are based on "Guidance for Estimating Downstream Dam Failure Hydrograph" confirm this classification. In the event the dam were to fail, excessive residential flooding would occur with potential for loss of life.

e. Ownership. The name and address of the current owner is:

Town of Winchester
Public Works Department
15 Lake Street
Winchester, MA 01890

The Town of Winchester is the original owner of the dam.

f. Operator. Mr. William Conlon, Operations Manager, is responsible for operation, maintenance and safety of the dam and has been associated with the Public Works Department for 23 years. His phone number is (617) 729-3503.

g. Purpose of Dam. The North Reservoir was originally constructed and is presently used as a water supply for the Town of Winchester.

h. Design and Construction History. Historical records indicate that the construction of North Reservoir Dam was first proposed in 1872, that a construction contract was let in September 1873 and that construction was completed in September 1874. The dam was designed by Walter H. Sears, an engineer from Boston, and was constructed by George H. Norman, a contractor from Newport, RI. No original design drawings or construction records were located.

1.2 Description of Project

a. Location. The dam is located at the northwest end of North Reservoir, in Winchester, MA, as shown on the Location Map, page vii. Spillway discharge from the dam is conveyed westward along Sawmill Brook and then through the drainage system of a developed area of town to reach the Aberjona River.

b. Description of Dam and Appurtenances. The North Reservoir Dam consists of a curved earth embankment, a gatehouse with two outlet pipes and an open channel spillway and weir. The total length of the embankment is estimated to be approximately 600 ft. The general configuration of the dam and appurtenances is shown on the "Site Plan Sketch", page C-1.

The embankment is described by H.S. Chapman in the "History of Winchester" as"a dam founded on solid ledge, with a core wall of stonework set in cement and a heavy wall of earth waterproofed with a layer of clay. The face of the dam is curved; its width at the bottom is one hundred and thirty feet and at the top thirteen feet. The top of the dam is twenty-eight and one half feet above the general level of the floor of the reservoir."

The top of the embankment is 13 ft. wide at El. 150.7 with side slopes of approximately 2 horizontal (H) to 1 vertical (V) downstream and 1.2H to 1V on the upper riprapped portion upstream. The lower portion of the upstream slope appears to be flatter. The upstream face has riprap wave protection below approximately El. 147.

The gatehouse is located on the upstream side of the embankment, approximately 200 ft. from the left abutment. Inlets consist of three levels of arched openings and a 24-in. diameter reservoir drain pipe. A 16-in. diameter water supply line leads from the gatehouse to a chlorination station located opposite the gatehouse, near the embankment toe. A 30-in. diameter blow-off pipe leads from the gate house to an unknown outlet location. Gatehouse details are shown on a drawing included as page B-8. Note that the elevations shown on the drawing are apparently referenced to a town datum and are equal to USGS Mean Sea Level elevation plus 5.47 ft.

An open channel spillway is located approximately 100 ft. beyond the right abutment. A concrete weir extends across the spillway channel. The weir is about 2 ft. high and consists of two 8 ft. long concrete sections separated by a 3 ft. wide opening with stop logs. The weir crest is about El. 147.2. There are numerous outcrops in the floor

PHASE I INVESTIGATION REPORT
NATIONAL DAM INSPECTION PROGRAM
NORTH RESERVOIR DAM
MA 00457

SECTION 1 - PROJECT INFORMATION

1.1 General

a. Authority. Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region.

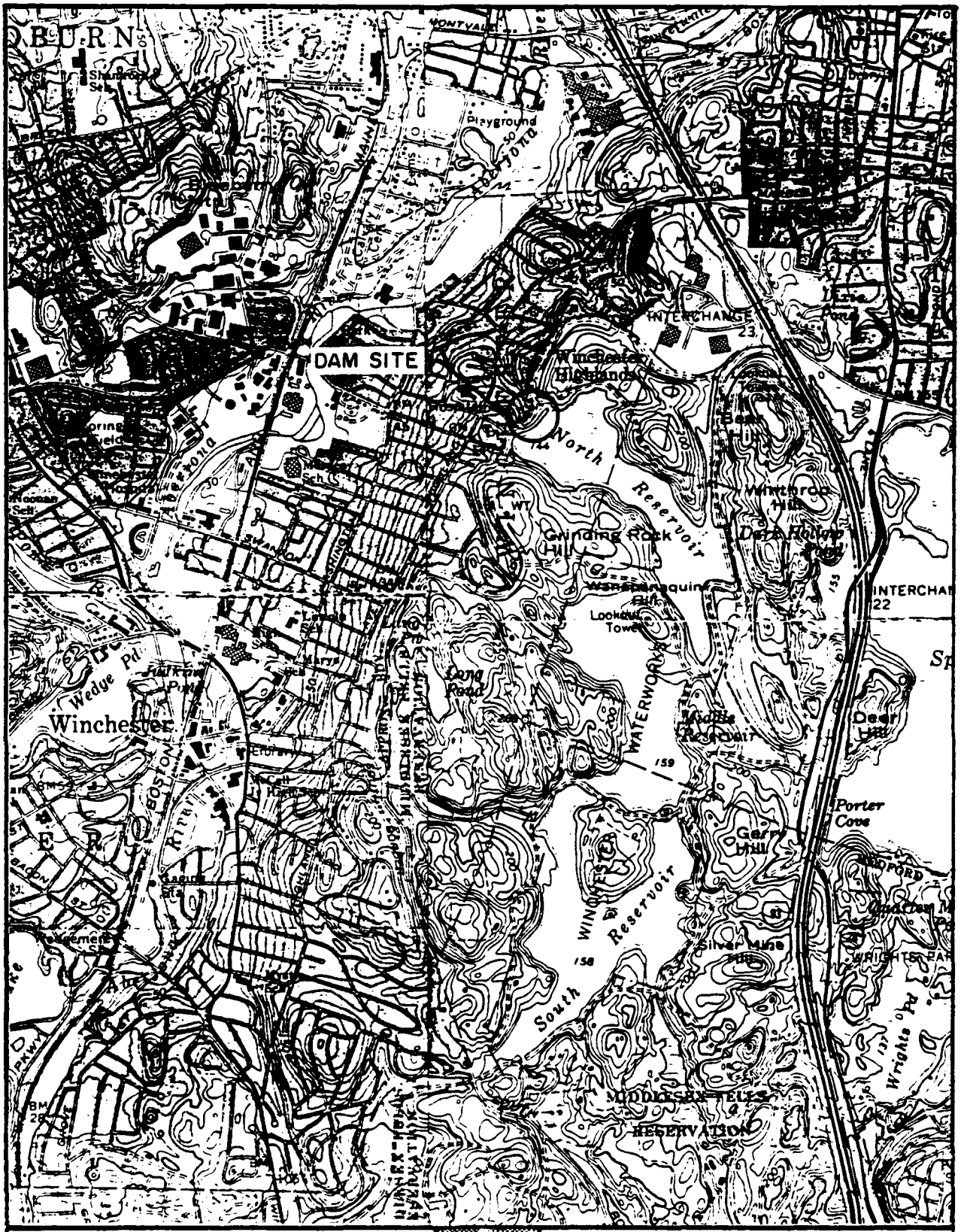
Haley & Aldrich, Inc. has been retained by the New England Division to inspect and report on selected dams in the State of Massachusetts. Authorization and notice to proceed were issued to Haley & Aldrich, Inc. under a letter dated 28 November 1978 from Colonel Max B. Scheider, Corps of Engineers. Contract No. DACW33-79-C-0018 has been assigned by the Corps of Engineers for this work. Camp, Dresser & McKee, Inc. was retained as consultant to Haley & Aldrich, Inc. on the structural, mechanical/electrical and hydraulic/hydrologic aspects of the Investigation.

b. Purpose of Inspection. The primary purposes of the National Dam Inspection Program are to:

1. Perform technical inspection and evaluation of non-Federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-Federal interests.

2. Encourage and prepare the states to initiate quickly effective dam safety programs for non-Federal dams.

3. To update, verify and complete the National Inventory of Dams.



FILE NO. 4270 A1

DAM: North Reservoir

IDENTIFICATION NO. MA 00457

N

LOCATION MAP

USGS QUADRANGLE

BOSTON NORTH, MA

APPROX. SCALE: 1"= 2000'

1. Downstream face of embankment viewed from right abutment

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SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. General. The earthfill embankment of the dam reportedly has a central core made of stone masonry with cement mortar. The construction was completed in 1874. The reservoir is used for water supply to the Town of Winchester. Available records indicate that spillage from the reservoir is infrequent and occurs in small quantities.

The North Reservoir yield can be supplemented by a limited quantity of water from the Middle Reservoir through a 10-in. diameter valved pipeline.

b. Design Data. No hydrologic or hydraulic design data were available for this dam site. The dam was designed by engineer Walter H. Sears of Boston.

c. Experience Data. As indicated in the Town's publications, the maximum known reservoir water surface elevation was 146.8, measured on 13 April 1936. This was about 1.5 ft. above the spillway crest and about 3.9 ft. below the top of the dam.

d. Visual Observations. The watershed of the reservoir consists of well maintained woodlands. At the time of the site visit the water surface in the reservoir was at a record low of El. 141.5 and the water line was about 100 ft. away from the spillway crest, which is at El. 145.2. The spillway section has been modified by the addition of a concrete weir with a crest elevation of 147.2. A 3-ft. wide rectangular notch at invert elevation 145.2 is located at the center of the concrete wall with provisions for stoplogs. The existing wooden stoplogs are badly deteriorated. The remnants of sandbags were observed around the spillway and were probably left from April 1970 when the water level was near the record high.

The spillway downstream channel is quite steep with portions observed to be partially blocked by large boulders and dense bushes.

Water for the Town may be withdrawn from the reservoir at three different levels through 3-ft. by 3-ft. arched openings at the gatehouse and conveyed through a 16-in. pipe to a chlorination station located at the toe of the dam.

e. Test Flood Analysis. Based upon the Corps of Engineers guidelines, the recommended test flood for the size (small) and the hazard potential (high) is within the range of 1/2 PMF to PMF (Probable Maximum Flood). The PMF was determined using Corps of Engineers guidelines for "Estimating Maximum Probable Discharge" in Phase I Dam Safety Investigations. The watershed terrain was determined to be midway between rolling and mountainous, and an inflow rate of 2,700 cfs per square mile was extrapolated for the drainage area of 0.58 square miles. The resulting PMF inflow is 1,560 cfs.

The 1/2 PMF inflow of 780 cfs was adopted at the test flood for this investigation. Surcharge-storage routing was performed through North Reservoir using the related stage-discharge and area-volume curves which are shown in Appendix D. The test flood outflow, which was estimated to be 175 cfs, would occur when water surface elevation in the reservoir is at elevation 149.0. The capacity of the water supply piping system was ignored in this evaluation. It is concluded that the spillway is adequate to pass the test flood, although it appears that the downstream channel does not have a comparable capacity.

f. Dam Failure Analysis. Based on Corps of Engineers Guidelines for Estimating Dam Failure Hydrographs and assuming that a failure would occur along a 165 ft. long section at the mid-height of the dam embankment, the peak failure outflow is estimated to be 15,600 cfs. The downstream channel runs through heavily developed sections of the Town after a distance of about 1,000 ft. from the dam. A "reach" between the dam and Highland Avenue was studied for the flood routing.

Storage volume of the reach (about 15 acre-feet) is negligible in comparison to the reservoir volume (860 acre-feet) at the time of the failure. Water depth in the downstream channel, resulting from a failure flood flow of 15,600 cfs, is estimated to be about 15 ft. A flow of this magnitude would cause a potential loss of life to people living in the nearby homes as well as damage to the structures. The impact area would include the intersection of Highland Avenue and Forest Street as well as the area between Forest Street and the Aberjona River. At least 10 homes which are presently occupied would be affected. Due to the potential loss of life and extensive property damage that would result from a failure of the dam, the hazard classification is considered high.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations. There was no visual evidence of instability of the earth embankment. Embankment crest width and side slopes are generally consistent with usual design practice and the embankment past performance has been satisfactory. In the absence of seepage problems, the embankment would be expected to be stable. However, slight seepage was occurring below the embankment toe and reservoir level was low. A higher reservoir level might result in changes in the seepage condition that could be significant with respect to embankment stability.

The spillway weir is noticeably out of alignment and has apparently experienced horizontal movement. The sides of the spillway channel including the low masonry walls along portions of the discharge channel appear to be stable.

b. Design and Construction Data. No records or drawings related to design or construction are available to aid the evaluation of structural stability.

c. Operating Records. There are no operating records available to aid the evaluation of structural stability.

d. Post-Construction Changes. There is no apparent evidence of significant structural changes in the embankment since original construction in 1874. The fact that the spillway weir is concrete indicates that the weir was not part of the original design. However, the date that the weir was added is unknown.

e. Seismic Stability. North Reservoir Dam is located in Seismic Zone 3. Pertinent data needed for a theoretical seismic stability analysis of the embankment are not available. Therefore, the stability of the embankment during an earthquake is unknown.

The spillway weir, which has apparently experienced horizontal movements previously, should not be considered stable during earthquake loading. However, it should be noted that the weir is only 2 ft. high and is founded directly on the ledge floor of the channel. Therefore, failure of the spillway weir is not likely to be a catastrophic event.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

a. Condition. The visual examination of North Reservoir Dam revealed that the dam structure itself was generally in good condition. However, the lack of an operative reservoir drain and the presence of seepage below the embankment toe necessitate an overall condition rating of fair. No signs of structural failure or other conditions which would warrant urgent remedial action were noted.

Based on the results of computations included in Appendix D and described in Section 5, the spillway is capable of passing the test flood, which for this structure is 1/2 the PMF, without overtopping the dam. With the water level at the top of the dam, the spillway has a capacity of 450 cfs with stoplogs removed. The test flood overflow of 175 cfs (372 csm) could be passed with a freeboard of about 1.7 ft. and unused surcharge-storage of 120 acre-ft. remaining.

b. Adequacy of Information. This evaluation of the dam is based primarily on visual examination, approximate hydraulic and hydrologic computations, consideration of past performance and application of engineering judgement. Generally the information obtained was adequate for the purposes of a Phase I assessment. However, additional information should be obtained relative to embankment seismic stability and the seepage condition below the embankment toe, as outlined in Section 7.2.

c. Urgency. The recommendations for additional investigations and remedial measures outlined in Section 7.2 and 7.3, respectively, should be undertaken by the Owner and completed within one year after receipt of this report.

d. Need for Additional Investigation. Additional investigations should be performed by the Owner as outlined in Section 7.2.

7.2 Recommendations

It is recommended that the Owner engage a registered professional engineer to undertake the following investigations and implement corrective action as required:

1. Assess potential vulnerability of the dam embankment to seismic events by conventional equivalent static load methods.

2. Investigate the seepage condition below the embankment toe and assess the need for remedial measures.

3. Evaluate the need to repair, remove or replace the concrete spillway weir.

In addition, the owner may wish the engineer to consider the potential for flooding of the area downstream of the dam in the event that the spillway is required to pass heavy flow.

7.3 Remedial Measures

The dam is generally in fair condition, and it is considered important that the following remedial work be undertaken by the Owner:

1. The outlet for the 30-in. blow-off pipe should be located and the blow-off system made operative to provide a means of lowering the reservoir in an emergency.

2. Seepage appearing in the swampy area below the toe of the embankment should be monitored on a regular basis, until an assessment of the need for remedial measures can be made. Particular attention should be paid during periods when the reservoir level is high. Significant changes in the seepage quantity or seepage pattern could indicate a problem within the dam embankment.

3. All brush, trees and other obstructions should be cleared from the spillway channel. The channel should be cleared at least once each year.

4. Copper roof flashing on the gatehouse should be repaired and the access bridge steel should be cleaned and painted.

5. The embankment should be cleared of brush and mowed at least once every year. After mowing, the embankment should be examined for evidence of animal burrowing activity and seepage.

6. Remove or replace the spillway stoplogs.

7. Repair localized erosion on upstream face of dam near crest.

In addition, the owner should prepare an operations and maintenance manual for the dam. The manual should include provisions for biennial technical inspection of the dam and for surveillance of the dam during periods of heavy precipitation and high reservoir water levels. The procedures should delineate the routine operational procedures and maintenance work to be done on the dam to ensure satisfactory operation and to minimize deterioration of the facility.

Because the dam is classified as having a "high" hazard potential, the owner should also develop a written emergency preparedness plan and warning system to be used in the event of impending failure of the dam. The plan should be developed in cooperation with local officials and downstream inhabitants.

7.4 Alternatives

Not applicable.

APPENDIX A - INSPECTION CHECK LIST

VISUAL INSPECTION PARTY ORGANIZATION

NATIONAL DAM INSPECTION PROGRAM

Dam: North Reservoir

Date: 6 December 1978

Time: 1030-1245

Weather: Clear, cool (40-50°F)

Water Surface Elevation Upstream: El. 141.5 NGVD

Stream Flow: None

Inspection Party:

Peter L. LeCount	- Soils/Geology
Richard A. Brown Haley & Aldrich, Inc.	
A. Ulvi Gulbey	- Hydraulic/Hydrologic
Joseph E. Downing Robert P. Howard Camp, Dresser & McKee, Inc.	- Structural/Mechanical

Present During Inspection:

William Conlon, Public Works Department, Winchester, MA

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: North Reservoir Dam DATE: 6 Dec 78

AREA EVALUATED	CONDITION
DAM EMBANKMENT	
Crest Elevation	El. 150.7 NGVD
Current Pool Elevation	El. 141.5 (Estimated)
Maximum Impoundment to Date	El. 146.8 on 3 April 1936 (according to town records)
Surface Cracks	None observed
Pavement Condition	No pavement, crest has earth stone-dust roadway, slightly eroded by auto traffic
Movement or Settlement of Crest	None observed
Lateral Movement	None observed
Vertical Alignment	Good
Horizontal Alignment	Good
Condition at Abutment and at Concrete Structures	Gatehouse bridge concrete abutment replaced in 1974. Left and right abutments grade into bedrock - in good condition
Indications of Movement of Structural Items on Slopes	None observed
Trespassing on Slopes	Limited access. Sign posted, some foot traffic, occasional vehicles and horses
Animal Burrows in Embankment	Several reported attempts made to exterminate animals. No burrows observed
Vegetation on Embankment	Mostly grass, some bush and small saplings on slopes
Sloughing or Erosion of Slopes or Abutments	Generally well vegetated, some local erosion near crest
Rock Slope Protection - Riprap Failures	12 to 18-in. stones, locally dislodged. Riprap extends up to approximately 4 ft. below crest
Unusual Movement or Cracking at or near Toes	None observed
Unusual Embankment or Downstream Seepage	Wet ground and local seeping at toe of fill that forms berm below dam: small swampy area approximately 50 ft. further downstream with two concrete walled pools, one with slight upflow; Town representative advised used to be

FILE NO. 4160
HALEY & ALDRICH, INC.
CAMBRIDGE, MASSACHUSETTS

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: North Reservoir Dam DATE: 6 Dec 78

AREA EVALUATED	CONDITION
	building over pool, which collected seepage for pumping back into reservoir
Piping and Boils	No soil particles observed in seepage
Foundation Drainage Features	None observed
Toe Drains	None observed
Instrumentation Systems	None
OUTLET WORKS - GATEHOUSE	
a. Concrete and Structural	
General Condition	Grouted masonry construction with a slate covered wooden roof which is well maintained and is in good condition
Condition of Joints	Good
Spalling	None observed
Visible Reinforcing	None observed
Rusting or Staining of Concrete	Not applicable
Any Seepage or Efflorescence	None observed
Joint Alignment	Good
Unusual Seepage or Leaks in Gate Chamber	None observed
Cracks	None observed
Rusting or Corrosion of Steel	None observed
b. Mechanical and Electrical	
Air Vents	None observed
Float Wells	None observed
Crane Hoist	None observed
Elevator	None observed
Hydraulic System	None observed
Service Gates	Manually operated wheel for gate of 16-in. service line
Emergency Gates	Rising stem manual gate operator for 30-in. blow-off pipe. Reported as not operative

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: North Reservoir Dam DATE: 6 Dec 78

AREA EVALUATED	CONDITION
Lightning Protection System	None observed
Emergency Power System	None observed
Wiring and Lighting System in Gate Chamber	OK
OUTLET WORKS - SPILLWAY WEIR, APPROACH AND DISCHARGE CHANNELS	
a. Approach Channel	
General Condition	Good
Loose Rock Overhanging Channel	None observed
Trees Overhanging Channel	None observed
Floor of Approach Channel	Good - some minor vegetation
b. Weir and Training Walls	
General Condition of Concrete	The concrete spillway weir is in fair condition. There are some minor cracks. The stoplogs are badly deteriorated. There is some horizontal movement observed at the stoplog opening. Remnants of sandbags observed behind the stoplogs
Rust or Staining	Some minor staining
Spalling	Some minor spalling
Any Visible Reinforcing	None observed
Any Seepage or Efflorescence	None observed
Drain Holes	None observed
Others	1-in. diameter pins embedded in the crest of the weir
c. Discharge Channel	
General Condition	Overgrown with vegetation and small trees

VISUAL INSPECTION CHECK LIST
NATIONAL DAM INSPECTION PROGRAM

DAM: North Reservoir Dam DATE: 6 Dec 78

AREA EVALUATED	CONDITION
Loose Rock Overhanging Channel	None observed
Trees Overhanging Channel	Some small trees and bushes
Floor of Channel	Heavy vegetation observed
Other Obstructions	Large rocks, culvert under access road
OUTLET WORKS - SERVICE BRIDGE	
a. Super Structure	
Bearing	Not observable - encased in concrete
Anchor Bolts	Not observable - encased in concrete
Bridge Seat	Not observable - encased in concrete
Longitudinal Members	Good - some minor rusting
Under Side of Deck	See deck
Secondary Bracing	Not applicable
Deck	Metal grate decking in good condition
Drainage System	Not applicable
Railings	In good condition
Expansion Joints	Not applicable
Paint	Longitudinal members need painting
b. Abutment and Piers	
General Condition of Concrete	Good - appears to be recent construction
Alignment of Abutment	Good
Approach to Bridge	Good
Condition of Seat and Backwall	Good

APPENDIX B - ENGINEERING DATA

LIST OF AVAILABLE DATA
NORTH RESERVOIR DAM

Document	Contents	Location
"Supply and Distribution Systems of the Public Water Works of Winchester, MA" 31 December 1894	Drawing showing North, South and Middle Reservoirs, 1" = 600 ft.	Town of Winchester Public Works Department 15 Lake Street Winchester, MA
"Historical Sketch of the Winchester, MA, Water Works, 1873-1933" by E.C. Sanderson, Journal of the New England Water Works Association, Vol. XLVIII, No. 3, 1934	Historical information including data on reservoirs	Barker Engineering Library, Mass. Institute of Technology (Appendix B)
"Town of Winchester, MA Detail Plan of Gatehouse, North Reservoir" by Parker Holbrook, Town Engineer, November 1943	Drawing showing North Reservoir Gatehouse	Town of Winchester Engineering and Planning Department, 71 Mt. Vernon Street, Winchester, MA (Appendix B)
"History of Winchester, MA," by H.S. Chapman, Vol. I, Chapter XV, 1975 ed.	Historical information on water system including description of North Reservoir Dam	Town of Winchester Public Library Department 80 Washington Street Winchester, MA
"Elevations of Winchester Water System", undated	List of reference elevations from 1937 Massachusetts Geodetic Survey	Town of Winchester Public Works Department 15 Lake Street Winchester, MA

Registrar has charge of the reading of meters, billing, and keeping all accounts. There has recently been installed a new set of books, and the department is equipped with a complete set of plans of street mains and services. All services are metered.

Meters are regularly tested about every five years. The department is equipped with a modern meter-testing outfit. When new services are installed the town pays for the work in the street and the customer pays for work on private property. Our standard ⅝-in. meters are furnished free. Larger meters are charged for, but a credit is allowed for the standard meter. Money for work to be done must be deposited with the Town Treasurer in advance. The Water and Sewer Department coöperates with the Highway Department by the exchange of equipment and men.

The department has rendered a number of free services to its customers. When it develops from meter readings that an excessive amount of water has been used, the meter is immediately re-read and if it has registered right, our meter man looks for leaks and if any are found he reports to the customer. The office then writes a letter stating that there are leaks in the house and recommends that a plumber be employed to make repairs. The customer is told the amount of the bill that he will receive. In this way the waste of water is stopped and the customer is prepared for a large bill. This method stops many complaints in regard to excessive bills. If a customer complains of poor pressure a man is sent to the house to investigate and report. Usually one of two things is the matter. The service may need cleaning or renewing, or the piping may be corroded so that the water will not flow. We clean a service for a flat price of $5.00. This cleaning, usually called a punch-out, is good for a few years. A record is kept on the service card at the Superintendent's office and the ledger card at the main office of punch-outs, and when the customer complains again he is advised to have his service renewed.

The water bills are made out by the Water Department and are payable to the Town Collector. A large number of the bills is paid before a summons is sent out, which costs 20c. This summons brings in many more bills. The accounts are then turned over to the Water Department which sends out a shut-off notice. Usually about 300 customers have to be threatened with a notice. We do exactly what the shut-off notice calls for on the date set. It is understood in the town that the department insists that the water bills be paid. When a customer calls at the office and claims that he cannot pay the bill he is told to go to the Welfare Department and get a certificate and that the bill will then be adjusted and that the Welfare Department will investigate and report. This scheme works. We have never had to make an adjustment. We believe that the welfare work of the town should be done by the Welfare Department and not the Water Department. On December 31, 1933 there were only 8 overdue water bills remaining unpaid, amounting to $35.18, out of a total billing of $50 603.33. The water has been shut off from all customers with overdue water bills. Eventually most of these bills will be paid. The shutting off of the water has not been a hardship to any customer. The houses where the services were shut off are vacant; the people moved out and did not pay the water bill. We hold the owners of the property responsible for the water bills, and we do not accept tenants as customers except in the case of a reliable business concern with good credit standing.

HARVARD UNIVERSITY.
HARVARD FOREST.
PETERSHAM, MASSACHUSETTS.

Town of Winchester,
Water and Sewer Board,
Town Hall, Winchester, Mass.

Gentlemen: In recommending a policy for the handling of forest growth on the watersheds of the Winchester reservoirs, I am considering the purposes which the tract is to serve, the type of forest which is most likely to fit the natural conditions, and finally the excellent plantations of pine which have already been established. Presumably the Town wants a forest that is permanent, most economical to maintain and protect, beneficial to soil and drainage, and satisfactory for park purposes. Experience has shown that the best type for such purposes is a mixed forest of varying age, such as the hardwood with hemlock and some pine which grew naturally in the locality. Such a forest generally means a porous and fertile soil, maximum resistance to fire, disease, and insect pests, and the opportunity for the management to keep it permanent by releasing younger trees from time to time as the old ones fail and have to be removed.

In comparison with this kind of forest a stand of pure pine, especially one where all the trees are of approximately the same size and age, has drawbacks. Fire is difficult to control and almost certain to kill all the trees. The stand is comparatively short lived; and when all the trees become old and mature, there being no younger generations on the ground, a new forest has to be started. A dense pure pine forest tends also to reduce soil fertility by building up a heavy layer of needles and duff which decomposes very slowly and sometimes causes the soil to become unduly compact. As to the relative permeability to water of soil under pine and under a mixed forest, there is, so far as I know, no quantitative knowledge. It is true that during the growing season hardwoods transpire much more water vapor than pines of equal leaf area; but on the other hand a very large amount of the rainfall, especially in spring, summer, and autumn, does not reach the ground at all through a pine stand, part being intercepted by the thick tree tops and still more by the matted duff on the ground; all of which goes back into the air by evaporation.

On such a watershed as yours, with bed rock so close to the surface, the effect of a given type of forest on surface drainage does not seem to me so important as the considerations of health and soil improvement, permanence, ease of protection, etc., as indicated above. With so much of the hardwood on your watershed already removed and so handsome a belt of pine plantations already established, it is not practicable to secure a mixed stand except very gradually and in particular areas or patches. I would suggest that no more of the larger hardwoods be cut; that the brushing out of small hardwood and underbrush between the planted pines should be confined to the larger stump sprouts or such shoots as are threatening to overtop the pine; that in places where the plantations are thin or in poor condition any thrifty seedlings or small saplings of oak, ash, or maple should be left to grow. This latter recommendation would apply only some distance back from the shore line, since the marginal belt of conifers is useful to keep out leaves and generally too large to admit an admixture of small hardwood.

If you decide to carry out these suggestions, I should be glad to come out from time to time and consult with Mr. Shea.

Very truly yours,
(Signed) R. T. FISHER,
Director.

November 18, 1933.

B-14

We have successfully used copper sulphate for destroying algae. A boat is equipped with an out-board motor and the copper sulphate is placed in bags and drawn through the water until it is dissolved. We usually shut off the reservoir while it is being treated. The State Department of Public Health is consulted before treating, and samples of the water are always sent to it before and after treating. The treatment has been successful so far, and the trouble usually clears up in a few days. Our system is very flexible and we can supply the whole town with water from either reservoir. The quality of the water is watched very carefully; samples are taken monthly and sent to the State Department of Public Health for examination.

The distribution system consists of about 54 miles of street mains that are of cast iron, with the exception of 4 448 ft. of cement pipe in good condition, 580 hydrants and 3 097 services, all of which are metered.

The pumping equipment consists of two electrically operated pumping stations. One is for the East High Service and takes water from the north piping system and the other is for the West High Service which takes water from the south piping system. The North Pumping Station has an auxiliary pump driven by a kerosene oil engine. This pump is used for emergencies only. The West High Service Station has two electrically operated pumps and in an emergency water can be had from Arlington for this district.

There is also a small automatic pump and catch basin below the North Dam, from which are pumped about 40 000 gallons of water per day from leakage through the dam, into the East High Service.

The electrical pumps in the main pumping stations are of the centrifugal type connected with 30-h.p. motors with hand starters and automatic stops. We believe that a man should visit the pumping stations and start the pumps as a safety measure.

There are two steel water towers of about 400 000 gallons capacity at either end of the East High Service connected by about two miles of 10-in. water main. The pump is near the North Tank and the water is pumped into the piping system and equalizes between the storage tanks, insuring a good volume of water throughout the East High System. The North Storage Tank was built in 1898 and is still in good condition. The South Storage Tank was built in 1929. On the West High Service there is a cement tank of 280 000 gallons capacity. This tank was built in 1912. About ten years ago it started leaking very badly and was water-proofed by the Western Water Proofing Co. It has been satisfactory ever since.

The personnel of the Water Department consists of a superintendent, foreman, two meter men, who read and repair meters, and seven workmen. Additional men are hired when needed. A Forester who acts as police guard is in charge of the watershed and reservoirs. One man is employed all the year and extra men are hired when needed.

The main office is at the Town Hall and is in charge of the Water Registrar. There is also another clerk in this office. There is an office at the shop which is in charge of the Superintendent with a clerk. The Water

been reflected in its efficiency. Few municipally owned plants can show such a good financial record as Winchester.

The Water Works as of Today.

The Winchester Water Works consist to-day of the three reservoirs situated in the Middlesex Fells in the towns of Winchester and Stoneham and in the city of Medford.

The North Reservoir supplies the North and East Sections of the Town, and the East High Service. The South Reservoir supplies the South and the West Sections of the Town, and the West High Service. The supply from these reservoirs is usually divided in the centre of the town, but the load on the reservoirs can be adjusted by changing the gates. The South Reservoir is 11.6 ft. higher than the North Reservoir when they are both full. In case of a bad fire the division gates are opened and both reservoirs feed the system. A water department man attends all fires to look after the interests of the Water Department.

The Middle Reservoir is between the North and South Reservoirs. It has a higher elevation and can flow into the other reservoirs. It is a storage basin and is used only when needed. It cannot be connected with the water mains.

There is a small district in the extreme westerly part of the Town for which water is purchased from Arlington. We are now building about one mile of 10-in. water main to connect this district with our West High Service. This work is being done with C. W. A. Funds. Uncle Sam is supplying the labor and a small part of the water pipe. The town is supplying the balance of the pipe, hydrants, etc., also the foreman and pipe-layers. The expense is about evenly divided.

There are no houses on the watershed of our reservoirs except the foresters cabin, garage and fire-tower, all owned by the town. The area of the watershed is 614 acres of which the town owns 247 acres. The balance is in the Middlesex Fells. The Town has the sanitary control of the entire watershed. The area of the water in the reservoirs is 198 acres, making a total area of land and water, of 812 acres.

The watershed is steep and rocky. It is completely forested with a mixed growth of trees. Two-thirds of which, or about 375 000 are coniferous trees of various kinds which were planted by the town. For fifteen years we have been planting four-year transplants. The other third are hardwood trees of various kinds.

We believe that the advantage derived from changing a hardwood growth to a mixed growth lies principally in the fact that the thick foliage of the pine trees retards evaporation in the summer time and delays the melting of the snow and ice in the spring, thus regulating the run-off of the watershed. The needles of the pine trees do not blow into the water of the reservoir and discolor it.

Where there is a mixed growth and a fire occurs, the land will not be entirely denuded of vegetation as would be the case with an all pine growth and the land will not be subject to excessive evaporation until new trees can be grown.

The pine trees are being attacked by a number of insects and diseases, among them the pine weevil, blister rust and the English pine-shoot moth. We consider the English pine-shoot moth the most dangerous. The forestry work is in the hands of a forester who has charge of the workmen and also acts as a police guard. The reservoirs are patrolled with an automobile equipped for fighting brush fires. There is also a fire tower which is used in dry weather as a lookout.

The Board decided that it should have some authority on forestry to look over the work on the watershed of the reservoirs. Mr. R. T. Fisher, Director of the Harvard Forest, came to Winchester on a number of occasions and gave careful consideration to the work with our forester. He presented a plan for the forestry work which the Board voted to carry out. (See p. 296).

formulated rules and regulations for the protection of the water and among them recommended that fishing be prohibited. In town meeting the regulations were accepted and became part of the regulations of the town. The present Water Board has had many suggestions in regard to allowing citizens to fish, but as transportation facilities from Boston come so near our reservoirs it would be impossible to properly protect the reservoirs if fishing was allowed.

As the town of Stoneham grew a number of houses were built on the watershed of the North Reservoir which extended almost to Stoneham Square, and the cesspools of these houses became a menace to the water supply. In 1899, on advice of the State Department of Health, all the land north and including Dykes Meadow was cut off from the watershed and in this way the town lost about one-third of the North Reservoir watershed.

In 1905 the Water Board recommended the general use of meters as a way of conserving water. In 1911 the Board felt the water supply had reached its limit as the reservoirs had not overflowed for some time. Mr. A. E. Whitney, who controlled all the water rights on the east side of the town and was much interested in Winchester, released the right to the water from Mollie's Brook which flowed into his mill-pond. The water was then diverted to the South Reservoir. Twenty-five acres of land were in this manner added to the South Reservoir watershed. As more meters were installed the demand on the reservoirs lessened and up to the present we have had an ample supply of water. The town is now completely metered.

On October 22, 1906 the Board of Sewer Commissioners was abolished and the duties were relegated to the Water Board.

When the Metropolitan Park Commission established a playground near the North Reservoir more people came from Boston and surrounding towns. The problem of properly guarding the reservoirs developed and after consultations with the Metropolitan Park Commission it was decided in 1912 to lease the reservoir lands for care and control to them. This did not prove to be a satisfactory arrangement as they were only interested in the park as a recreation center. In 1917 the Water Board felt that this created a menace to the water supply and, by vote of the town, the Water and Sewer Board cancelled the agreement with the Park Commission and an inspector was appointed to report conditions to the Board. In 1918 a forester with police powers was appointed to take charge of the reservoir grounds. He was furnished with a horse, and a log cabin was built for headquarters.

During the winter of 1918 fuel was very high and scarce. It was suggested that the Board authorize the cutting of trees bordering the reservoirs by the citizens for fuel. This the board granted and the work was started. It was decided to plant pine trees on this cleared land so that as they increased in size they would act as a barrier to keep the leaves of the hardwood trees from blowing into the reservoirs thus affecting the color of the water. Since then, a systematic planting of pine trees has been carried on under the advice of the State Department of Forestry. In 1927 the work

of planting trees was completed at a cost of $50 000. About 380 000 of various kinds of pine were used. The hardwood trees are being gradually thinned out as the pine trees make a good ground cover.

During the last few years much work has been done on the watershed. All low and marshy places have been drained so that the water will flow quickly into the reservoirs and not become colored by standing or lost by evaporation. This has proved its worth as undoubtedly the amount of water recovered from the watershed has been increased.

In 1924 the residents of the Dunster Lane section, which lies at the extreme westerly end of the town near the Arlington line, petitioned for water. As they were a long way from the Winchester supply, arrangements were made with Arlington to supply this district. In 1925 Winchester laid the mains and is purchasing water from Arlington to supply about 25 customers.

In 1929 and 1930 the reservoirs were drawn very low on account of dry weather, and the Board asked the town to appoint a committee to investigate all matters pertaining to the Water Department and also means of increasing the water supply. The excessive rain in the fall of 1932 almost filled the reservoirs and the spring rains of 1933 caused them to overflow. The Water Board has had the water system of the town connected with Arlington and Stoneham, who use the Metropolitan water supply, and the City of Woburn, having an ample supply of its own. Engineers have made a careful survey of the water works and state that the consumption of water about equals the supply and that in a few years the town will be obliged to enlarge the supply. The Water Department is equipped with all the necessary instruments for keeping accurate records of the water supply.

In 1926 a large real estate development was started on the high land off Highland Avenue in the southerly part of the town known as Symmes Park. It soon developed that there was not an adequate water supply for fire purposes, and the Water Board presented two plans to take care of this condition: one, to build a new feeder pipe from the North Tank, a distance of about 9 000 ft., at an approximate cost of $50 000; the other plan was to erect a storage tank at Symmes Park at a cost of $20 000. The Finance Committee recommended to the town the storage tank, and in 1929 the town unanimously voted the appropriation, and it was built.

In 1929 a new shop was purchased on Lake Street. This shop and garage is modern in every particular and is a great asset to the department.

There has always been a leak at the base of the North Dam, and in 1930 a well and pump-house were built to recover this leakage which amounts to about 40 000 gallons per day and is pumped into the east high service.

In 1930 the Sewer Department was consolidated with the Water Department under one superintendent. This was done so that the departments could be more economically operated.

Many well known engineers and business men have given freely of their time to the town to carry on the Water and Sewer Departments. This has

were completed in September, 1874. During this time pipes had been laid in a number of streets in the town and on September 20 water was turned on. There was no charge made for water until November 1, 1874. The first Water Registrar began his duties November 1, 1874. Mr. William T. Dotten was appointed Superintendent the same year and served the town until his death in 1925 making a continuous service for 50 years. At his death his son, Mr. Harry W. Dotten, was elected Superintendent and is now serving the town. In the past 60 years the Water Works has had only two Superintendents.

Soon after the completion of the Water Works there arose a demand for water by the citizens living on the east hill which could not be reached by the gravity supply. In 1885, a high service line was built in Highland Avenue and a basin blasted out of the rock at the present site of the North Tank. The water was pumped by a windmill situated at the North Dam. This arrangement did not prove adequate and a steam pump was installed in 1888. A new iron tank was erected on the hill near the North Reservoir in 1898. This tank is still in good condition and will serve for many years.

In 1888 a new house was built near the North Reservoir for the Superintendent. In the basement of this house was constructed a pumping plant to replace the windmill. It was not put into active operation until 1892. The present pump-house was built in 1898. It was equipped with a kerosene engine and pump which did duty until 1915 when it was replaced by an electric pump. In turn this pump has been replaced with a modern pump with larger capacity and higher efficiency.

As the water pipes were extended through the town and more people became water-takers, it became evident that the North Reservoir would not supply the demand and at a town meeting held November 20, 1880 "the Water Board was instructed to proceed, as speedily as prudence would permit, to purchase all the land for the South Reservoir and to commence the building of the same." The Water Board procured the services of Walter H. Sears who made the surveys for the whole system. It was decided to build a dam of earth similar to the one at the North Reservoir with a cement core in the center and to prepare a basin for water. This proved to be a very large undertaking for the town, but after 10 years, the work was completed. There were held many town meetings and a great deal of oratory was expended on the project but the Water Board at that time knew enough not to ask for the full amount of money necessary to complete the work at one time but fed it to the citizens by degrees and eventually completed the work. When the reservoir was completed the northern end was very shallow and, on advice of the State Department of Health, a dam was built dividing what we now call the South and Middle Reservoirs, in that way raising the level of the water in the shallow area. The shores of the South Reservoir are very steep and rocky and there has been very little trouble with the quality of the water from the South Reservoir. The Middle Reservoir for the first few years gave much trouble with bad-tasting water, but for the last 15 years the water has been of excellent quality. In 1893 the South Reservoir was connected with the town system at Symmes corner thus making a very flexible system, as either the North or South Reservoirs can now be used to feed the whole town and the Middle Reservoir can feed either the North or South Reservoirs.

In 1903 there developed a demand for water on the west side hills which could not be supplied from the gravity system, so a booster pumping station was built on Myopia Road near Cambridge Street and a wooden high service tank built on Andrews Hill which was replaced by a cement tank at a higher elevation in 1912. This station is equipped with two electric pumps. It was originally equipped with an oil engine and pump, but the neighbors objected to the noise and it was changed.

In 1894 the first survey of the streets was made, and while the engineers were at work it was deemed advisable to have the watershed resurveyed and the amount of water in the reservoirs definitely determined. A very valuable piece of work was done, and it has been of great help in keeping records of the water supply.

In 1880 the Water Department commenced manufacturing its own cement-lined pipes. It had a plant in back of the old Water Works Shop on Vine Street and for about five years, manufactured all the small pipe that was used in the town. The pipe consisted of an outside casing of wrought-iron riveted together and lined with about an inch of cement. This pipe proved very satisfactory but has been gradually removed as the town grew and larger pipes were required. There is very little now remaining in the streets.

In reservoirs where the basin has not been cleaned of all stumps, loam, and vegetable matter, it takes from 10 to 12 years to reach the same quality of water as in a basin that has been cleared to gravel and in 1879 much trouble was experienced with the water in the North Reservoir. Different authorities were consulted and it was ascertained that the quality of the water was safe for drinking but the taste was very disagreeable. Suggestions were made that a filtering plant be built at the base of the dam, that water be pumped from Mystic Pond, or a connection be made with Woburn, but nothing was done and when the winter came on, the situation cleared up. The next year the quality of the water was good again. We now know the trouble with the water came from algae. In 1932 algae developed but were discovered before they reached the piping system and the reservoir was shut off and treated. The State Department of Health examined the water in the reservoirs about once a month for microscopic organisms and bacteria.

When the North Reservoir was placed in service 115 black bass weighing from three-quarters of a pound to two pounds each were put into the reservoir. In 1880 it was decided to grant permits for fishing. A number of controversies over this matter developed during the following years. From time to time fishing was allowed and abuses developed and the privilege was rescinded until, by vote of the town, the State Department of Health

The reservoirs when full contain 993 600 000 gallons of water, distributed as follows:

	m. g.
North Reservoir	255.9
Middle Reservoir	187.6
South Reservoir	550.1

It was estimated by the early engineers that the watershed would yield a million gallons per day per square mile and that the safe draw-down of the reservoirs would be as follows:

	m. g.
North Reservoir — 10 feet or	159.0
Middle Reservoir — 7 feet or	118.6
South Reservoir — 10 feet or	233.6
Total	511.2

The cost of the reservoirs and land according to the Auditor's report of 1905 was $262 108.04.

The first account we are able to find of any public action taken in regard to the introduction of water for domestic purposes into the town is in the record of the town meeting held Tuesday, November 8, 1870, when a committee of nine was appointed. This committee made a partial report at the town meeting held November 27, 1871, and asked to be, and was discharged. At the same meeting a committee of five was appointed by the chairman, "to investigate and report, as soon as practicable, the question of supplying the town with water," this committee was also "empowered to employ assistance and make examinations at the expense of the town." At the town meeting held March 25, 1872, this committee made a written report to the effect that it had examined.

First — "The Holly System, and was of the opinion that it was "not available for Winchester."

Second — The Winter and Wedge Pond source, and that it was then endeavoring to secure the passage of an Act of the Legislature, enabling the town to take water from this source.

Third — That it had conferred with the towns of Arlington and Woburn. The Committee says "Both towns seem disposed to supply us, but on what terms we cannot tell; neither of the towns being in a condition to give them."

On August 3, 1872, a town meeting was held and a committee of five was appointed to investigate the whole subject of water supply and the cost of construction and to report to the town. Part of the Committee's report follows:

> It was determined to ascertain whether either Charlestown, Arlington, or Woburn, could furnish the town with a supply of water on such terms as would be advantageous and also to investigate all other possible opportunities available for the town to supply itself.
>
> Previously to the appointment of the Committee, the town had procured and accepted an act from the General Court, authorizing the taking of water from Winter and Wedge Ponds. During a discussion relative to the features of the water supply from the ponds named, a member of the Committee suggested the watershed along the easterly line of the town, a portion of which is known as Turkey Swamp, as possibly of sufficient height to supply the inhabitants by gravity.
>
> A meeting of the Committee was immediately arranged to perambulate the streets of the town, with Mr. George H. Norman, of Newport, R. I. — a man of very large and varied experience in matters pertaining to waterworks,— to form some judgment as to whether pipes could probably be laid without much rock cutting. Accordingly, on the 2nd day of September, the Committee and Mr. Norman met, and during the afternoon a visit was made to the high land overlooking a large part of the valley referred to. Mr. Norman's practical experience enabled him at once to say that he thought there might be a square mile (640 acres) of reliable watershed, and made the remark, that if that quantity of land was available, there was no possible doubt that a million (1 000 000) gallons per day coud be depended upon, provided the water could be retained by suitable artificial dams. He also strongly urged that a reliable survey of the premises should be made.
>
> The Committee determined to cause a proper survey to be made of the watershed of Winter Pond, and also of the territory on the east side of the town, just described. At a meeting held October 5, the Committee by vote authorized the engagement of the services of Mr. Walter H. Sears, Civil Engineer, to make the proposed surveys. They were entered upon at once and prosecuted with great industry, and the field work was completed before the winter's snow seriously interfered with it, the last of the work being done while some snow was on the ground.
>
> The result of the survey brought to light the facts that Winter Pond could not be depended upon as a source for a sufficient supply, and that source was dismissed; also that Wedge Pond, although yielding an ample quantity, was contaminated by the drainage of the streets of the town, and consequently its waters would become more and more impure as the population of the town should increase.
>
> The water of either Winter or Wedge Ponds would have to be pumped; whereas the supply on the easterly side of the town could be so ponded by artificial dams (at moderate expense) that a supply for at least 20 000 people could be procured by gravity. This water is of great purity, there being nothing to contaminate it on the land nor in the air above. The Committee became so interested in this new-found supply,— especially in the fact that it can be delivered by its own gravity to a height at least 100 feet above the rail track at Main street crossing,— that they determined to ask the Legislature, then in session, to grant an act authorizing the town to secure the territory for the purpose of a water supply.

At the town meeting held March 24, 1873, it was voted to accept the Act of Legislature giving the town the right to establish a water system and elect three Water Commissioners.

At a town meeting held August 2, 1873, it was voted by the town to instruct the Water Commissioners to make no further contracts until the adjournment of the town meeting and that the Water Commissioners confer with the authorities of the Town of Woburn and ascertain the lowest terms upon which the Town of Winchester could be supplied with pure water by said Town of Woburn and said Committee to report at the time to which this meeting shall be adjourned. On November 4, 1873, a report was made in regard to taking water from Woburn, and, since it decided that it was not feasible the Commissioners were authorized to proceed with the work. Meantime, the Commissioners had let a contract to build the North Dam and on September 6, 1873, the work was started. The dam and reservoir

HISTORICAL SKETCH OF THE WINCHESTER, MASSACHUSETTS, WATER WORKS. 1873–1933.

BY E. C. SANDERSON.*

[Received February 16, 1934.]

Sixty years ago, the construction of the Winchester Water Works was begun, and the water began to fill the North Reservoir on December 5, 1873, but owing to the partially completed state of the dam, it was not deemed advisable to fill the reservoir until the following year. During 1874 pipes were laid, and water was turned on to the piping system on September 20, 1874.

The reservoirs were created by the construction of dams so that certain natural basins could be used for the collection and storage of water. They are three in number, known as the North, Middle and South Reservoirs.

The watershed tributary to the reservoirs is remarkable in that there is not a house upon it.

The reservoirs are so located that pumping is necessary for a limited portion of the town, the larger part being supplied by gravity.

The area of the watershed is about 812 acres divided as follows:

	Acres
Watershed on State Land	367.03
Land area owned by the town around the reservoirs including right of way to Main Street	246.77
Area of Reservoirs when full	198.02
Total	812.00

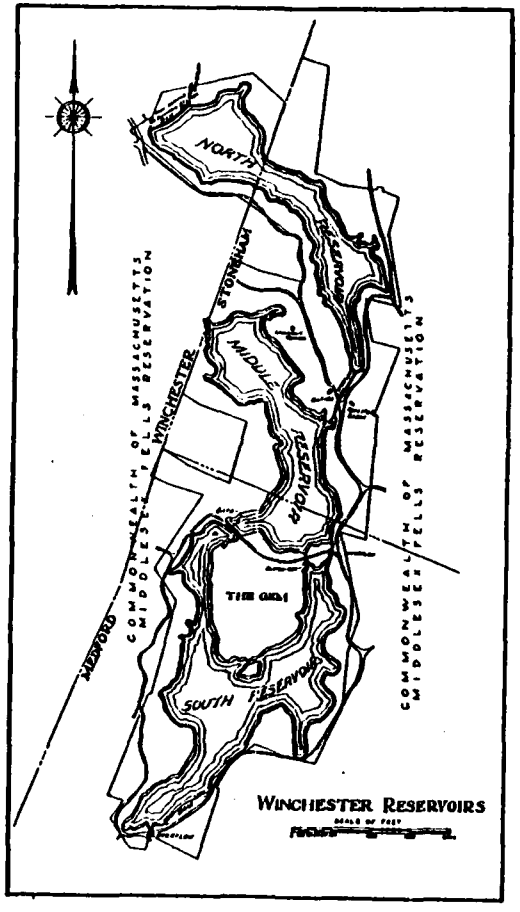
The area of the reservoirs when full is about as follows:

	Acres
North Reservoir	59
Middle Reservoir	58
South Reservoir	81
Total	198

The area of the watershed (land surface) is distributed as follows:

	Acres
North Reservoir	258
Middle Reservoir	134
South Reservoir	222
Total	614

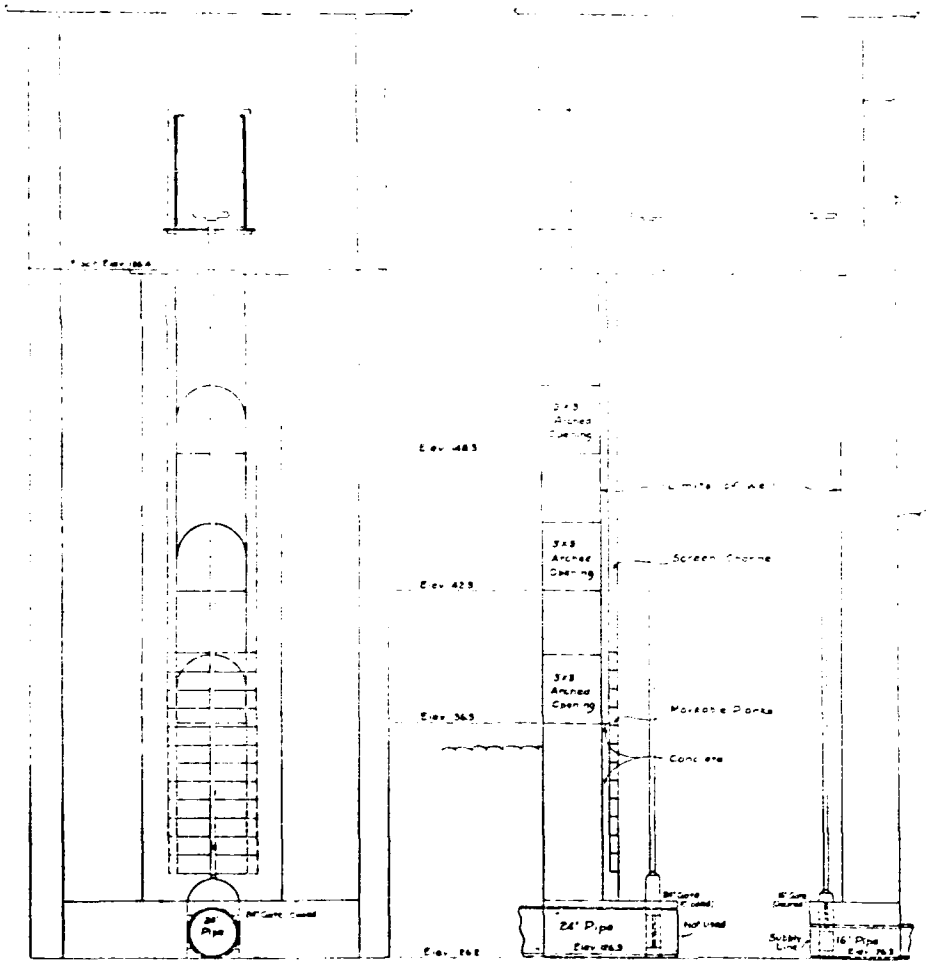
*Chairman, Water and Sewer Board, Winchester, Mass.



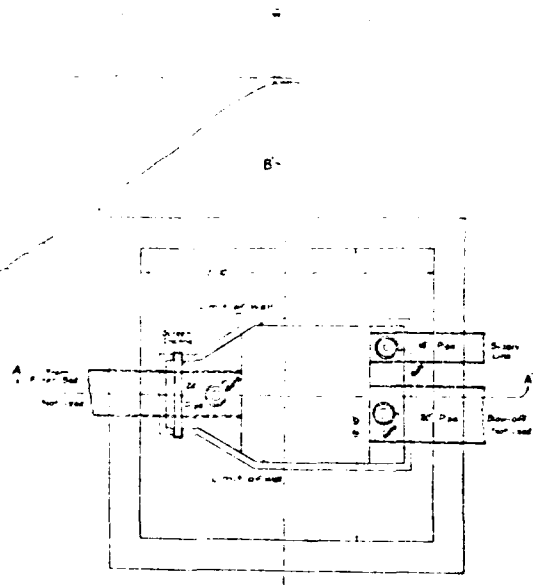
TOWN OF WINCHESTER MASS.
DETAIL PLAN OF GATE HOUSE
NORTH RESERVOIR

Scale: ½ in. = 1 ft November, 1943

Parker Holbrook Town Engineer



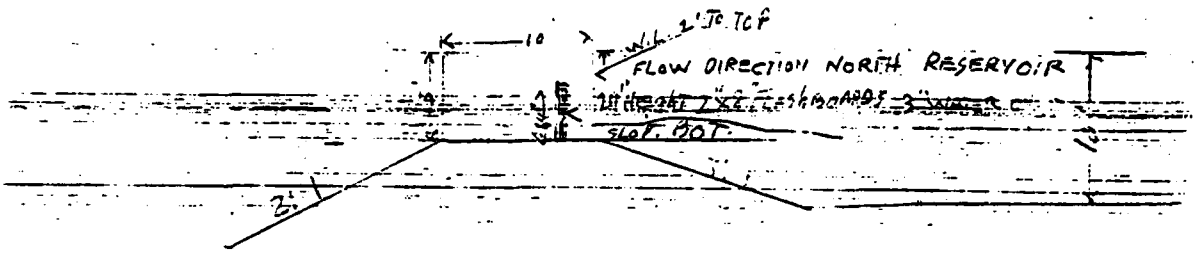
SECTION B-B' SECTION A-A'



FLOOR PLAN

TOSE

4-9-344-1



X SECTION AA

NOT TO SCALE

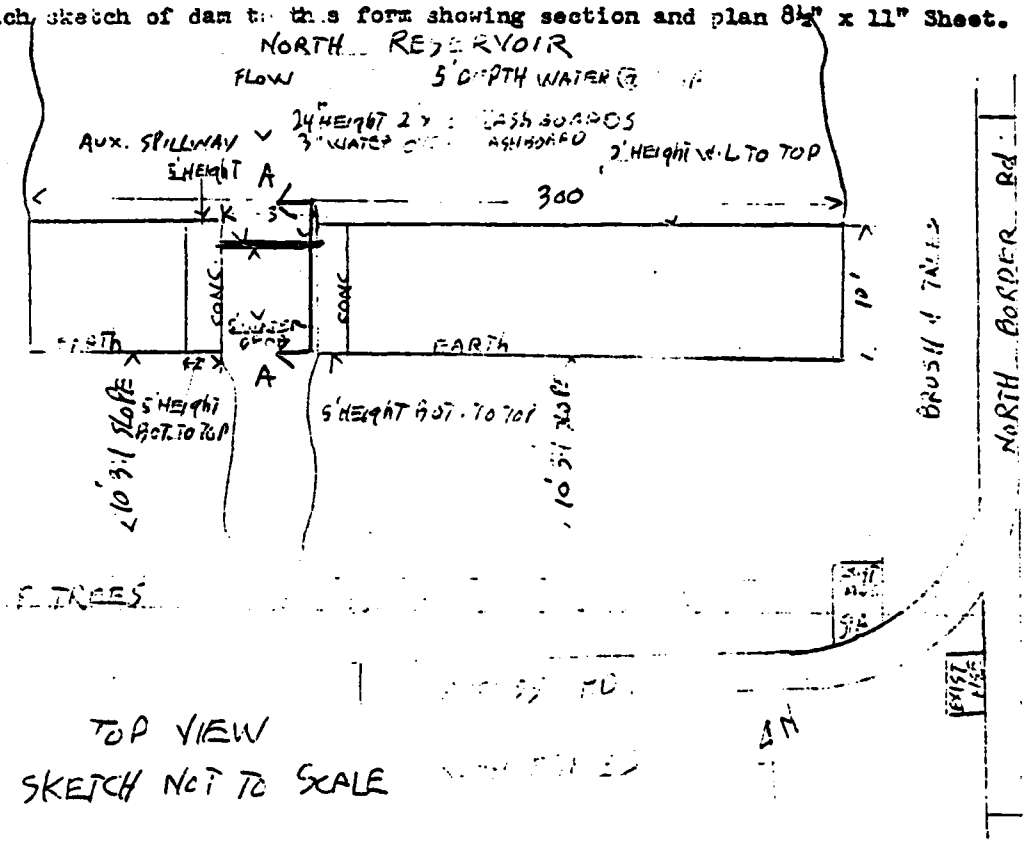
DAM NO. 4-9-344-4

10.
Risk to life and property in event of complete failure.

No. of people 100
No. of homes 34
No. of businesses NONE
No. of industries 1
No. of utilities 1
Railroads NONE
Other dams 1
Other

Type
Type

11.
Attach sketch of dam to this form showing section and plan 8½" x 11" Sheet.



DESCRIPTION OF DAM
DISTRICT #4

Submitted by FRANCIS H. FAREFACAM & D. PIZAN Dam No. 4-9-344-1
Date 3-27-74 City/Town WINCHESTER
Name of Dam ERIE RESERVOIR DAM

1. Location: Topo Sheet No. 318
~~Provide 8½" x 11" in clear copy of topo map with location of Dam~~
clearly indicated.

2. Year built: UNKNOWN Year/s of subsequent repairs UNKNOWN

3. Purpose of Dam: Water Supply ✓. Recreational
Irrigation. Other

4. Drainage Area: 0.5 SQ. MI. 320 ACRES.

5. Normal Ponding Area: 72 acres; Ave. Depth 5'
Impoundment: 120 MIL. gals; 360 acre ft.

6. No. and type of dwellings located adjacent to pond or reservoir
i.e. summer homes etc. 1 PERMANENT HOME & AUX. FIRE STATION ADJ. TO DAM

7. Dimensions of Dam: Length 300' Max. Height 10'
Slopes: Upstream Face 3:1
Downstream Face 2:1
Width across top 10'

8. Classifications of Dam by Materials:
Earth ✓. Conc. Masonary ✓. Stone Masonary
Timber. Rockfill. Other

9. A. Description of present land usage downstream of dam: 80% rural;
20 % urban
B. Is there a storage area or flood plain downstream of dam which could accommodate the impoundment in the event of complete dam failure
no ✓, yes

DAM NO. 4-9-344-1

(12) Remarks & Recommendations: (Fully Explain)

DAM IS IN GOOD CONDITION.

(13) Overall Condition:

1. Safe ✓
2. Minor repairs needed _____
3. Conditionally safe - major repairs needed _____
4. Unsafe _____
5. Reservoir impoundment no longer exists (explain)

Recommend removal from inspection list _____

DAM NO. 4-9-344-1

(8) Downstream Face of Dam: Condition: 1. Good ✓ 2 Minor Repairs____

3. Major Repairs____ Urgent Repr___

Comments:_____

(9) Emergency Spillway: Condition: 1. Good ✓ 2. Minor Repairs____

3. Major Repairs____ 4. Urgent Repr___

Comments:_____

(10) Water level at time of inspection 0.2 ft. above ✓ below____

top of dam____ Principal spillway ✓

other_____

(11) Summary of Deficiencies Noted:

Growth (Trees or Brush) on Embankment BRUSH ON EMBANKMENT

Animal Burrows and Washouts_____

Damage to slopes or top of dam_____

Cracked or Damaged Masonry_____

Evidence of Seepage_____

Evidences of Piping_____

Erosion_____

None_____

OK FILE

INSPECTION REPORT - DAMS AND RESERVOIRS

(1.) Location: ~~City~~/Town WINCHESTER DAM NO. 4-9-344-1

Name of Dam NORTH RESERVOIR DAM Inspected by A.Z. PIZANI & E.H. PARE

Date of Inspection 3-27-'74

(2.) Owners: pvt: Ass. ✓ Prev. Inspection

Reg. of Deeds Pers. Contact

1. TOWN OF WINCHESTER 71 MT. VERNON ST. 729-3503
Name St. & No. ~~City~~/Town State Tel.No.
WINCHESTER, MASS. - 01890

2. Name St. & No. City/Town State Tel.No.

3. Name St. & No. City/Town State Tel.No.

(3.) Caretaker: (if any) e.g. superintendent, plant manager, appointed by absentee owner, appointed by multi owners.

SAME
Name St. & No. City/Town State Tel.No.

(4.) No. of Pictures taken NONE

(5.) Degree of Hazard: (if dam should fail completely)*

1. Minor ✓ 2. Moderate

3. Severe 4. Disastrous

*This rating may change as land use changes (Future Development)

(6.) Outlet Control: Automatic Manual ✓

Operative ✓ Yes: no.

Comments:

(7) Upstream Pond or Pool: Condition:

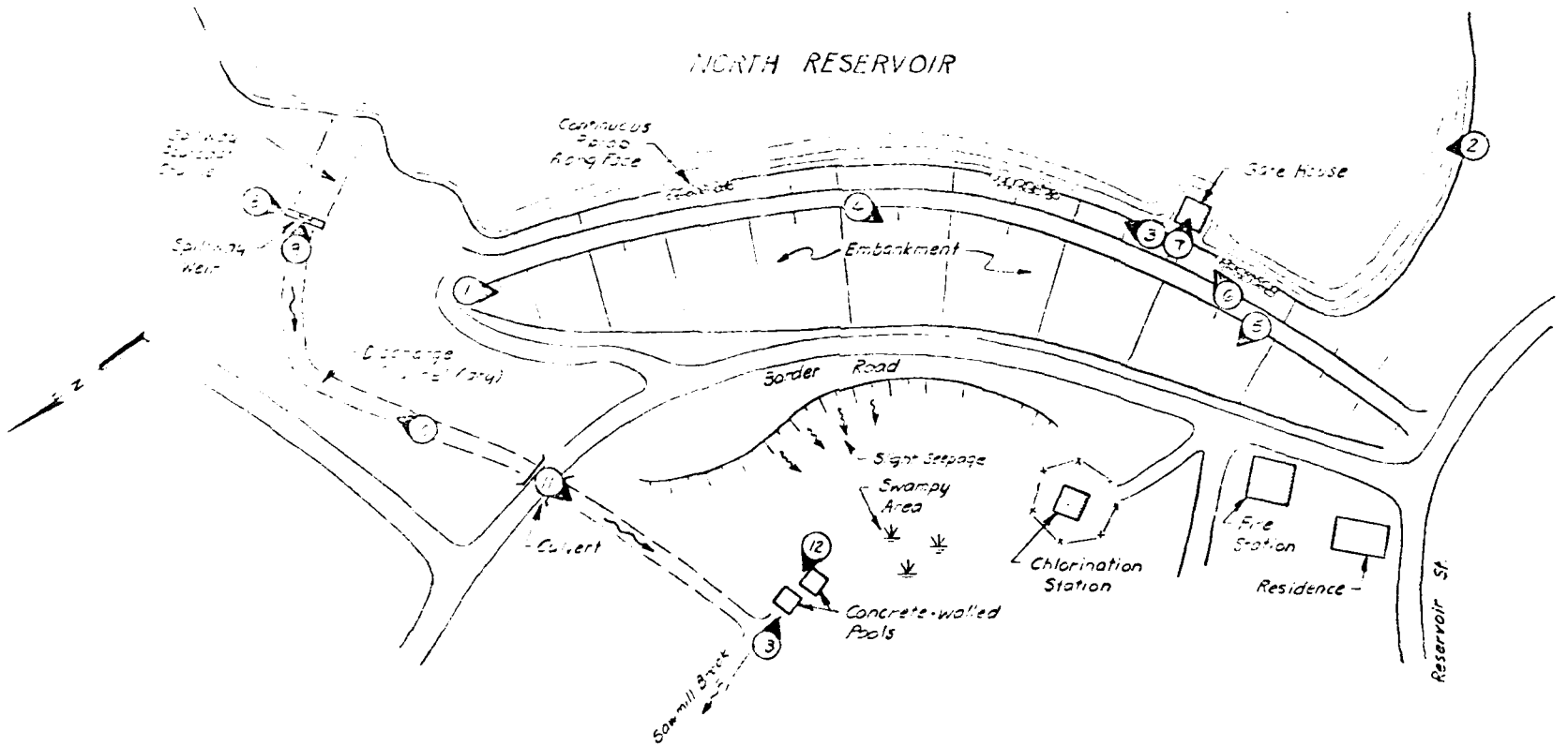
1. Good ✓ 2. Minor Repairs

3. Major Repairs 4. Urgent Repairs

Comments:

APPENDIX C - PHOTOGRAPHS

No.	Title	Roll	Frame	Page
1.	Downstream face of embankment viewed from right abutment	C29	13A	vi
2.	Upstream face of embankment viewed from near left abutment	C29	20A	C-2
3.	Upstream face of embankment viewed from gatehouse	6	11	C-2
4.	Downstream face of embankment	C29	14A	C-3
5.	Chlorination Station	8	5	C-3
6.	Gatehouse	C29	17A	C-4
7.	Gatehouse interior	C29	1A	C-4
8.	Spillway weir	C28	33A	C-5
9.	Spillway approach channel	C28	35A	C-5
10.	Spillway discharge channel, upstream from culvert	C28	36A	C-6
11.	Spillway discharge channel, downstream from culvert	C29	11A	C-6
12.	Concrete-walled pools	6	15	C-7
13.	Overflow from concrete-walled pools	C29	10A	C-7



NOTE

PLAN DEVELOPED FROM VISUAL OBSERVATIONS MADE DURING SITE VISIT ON 6 DECEMBER 1978.

LEGEND

(4) PHOTO NO. AND DIRECTION OF VIEW.

North Reservoir Dam
Winchester, MA

SITE PLAN SKETCH

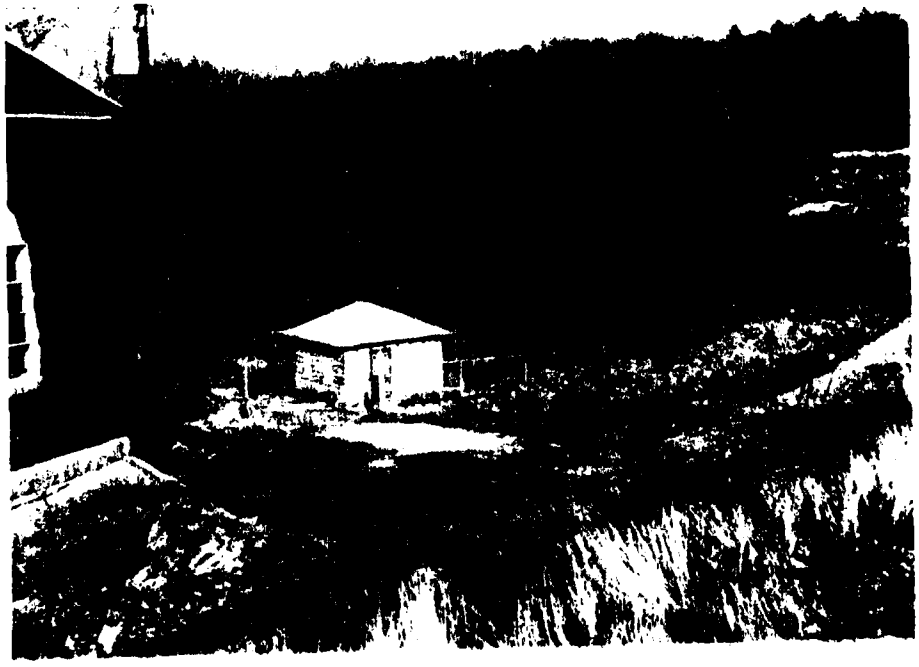
No Scale February 1979

4270

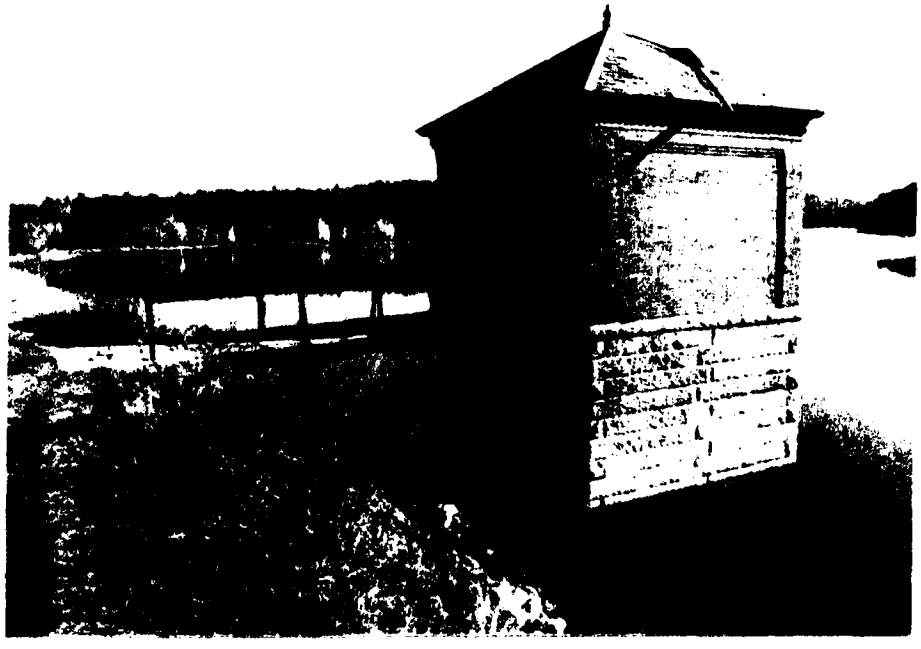
2. Upstream face of embankment viewed from near left abutment

3. Upstream face of embankment viewed from gate-house

4. Downstream face of embankment



5. Chlorination Station



6. Gatehouse

7. Gatehouse interior

8. Spillway weir

9. Spillway approach channel

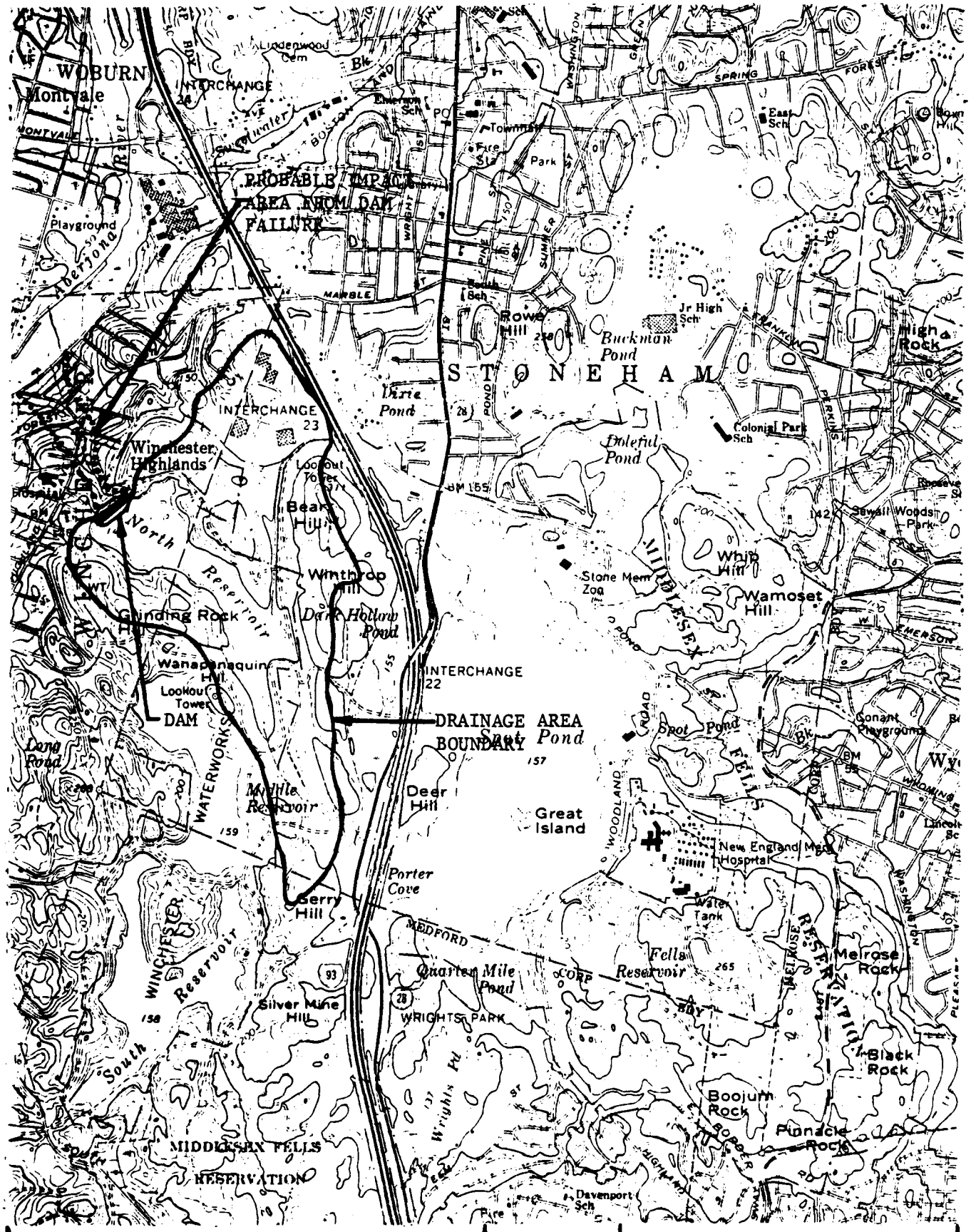
10. Spillway discharge channel, upstream from culvert

11. Spillway discharge channel, downstream from culvert

12. Concrete-walled pools

13. Overflow from concrete-walled pools

APPENDIX D - HYDROLOGIC AND HYDRAULIC COMPUTATIONS



CAMP DRESSER & McKEE Inc.
Consulting Engineers
Boston, Mass.

N

NORTH RESERVOIR DAM
DRAINAGE AREA AND
FLOOD IMPACT AREA
SCALE: 1:24,000

Size classification

Hydraulic height : $150.7 - 123.5 \approx 27$ -feet < 40-ft.

Reservoir Storage @ top of Dam : 860 acre-feet $<$ 1000 ac-ft.

Size classification : Small

Hazard Potential

The downstream channel bed disappears at a distance of about 1000-ft downstream from the dam. The stream is connected to a drain which carries flows to the Aberjona river. In the event of a dam failure the capacity of the channel would be greatly exceeded, creating a potential for loss of life and extensive property damage along the stream bed. Therefore the hazard potential is HIGH.

Test Flood

Size Small & hazard high : Test Flood : $\frac{1}{2}$ PMF to PMF

Drainage Area : 370 acres = 0.58 sq mi

PMF rate : 2700 cfs/sq mi ; PMF = 1560 cfs.

Probable Maximum Flood Inflow : 780 cfs.

Surcharge - Storage Routing

Q_{P_1} = 780 cfs → WSE = 151.0 (See Spillway Stage-Discharge curve, p. D-4)

Res. Vol. = 875 ac-ft (See Area-Volume Curve, p. D-5)

Normal Res. Vol. @ El. 145.25 : 500 ac-ft

Surcharge Volume : 375 acre

STOR 1 = $\frac{375 \cdot 12}{370}$ = 12.16 -in $\quad Q_{P_2} = 780\left(1 - \frac{12.16}{9.5}\right) = > 0$

Assume STOR 2 = 0 $\quad STOR_{AV}$ = 6.08 -in

Q_{P_3} = 280 cfs → WSE : 149.65 Res. Vol. : 780 ac-ft.

$STOR_3$ = 9.08 -in $\quad STOR_{AV}$ = 7.58 -in

$Q_{P_4} = 780\left(1 - \frac{7.58}{9.5}\right) = 156$ → WSE : 148.80
Res. Vol. = 720 ac-ft.

STOR 4 = 7.14" → $STOR_{AV}$ = 7.36 -in $\quad Q_{P_5}$ = 175 cfs

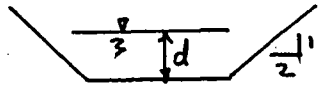
WSE = 149.° ≃ 148.80

TEST FLOOD OUT FLOW: 175 cfs. (The existing outlet capacity was ignored)

Downstream Channel

$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$

$n = 0.04 \quad S = \frac{145.7 - 127.5}{210} = 0.085$



$Q = 10.8\ A\ R^{2/3}$

d = 2 -ft → Q = 260 cfs > 175 cfs.

During the test flood outflow, water depth in the channel would be less than 2 feet and no flow back-up is expected until the junction with the Old Saw Mill Brook.

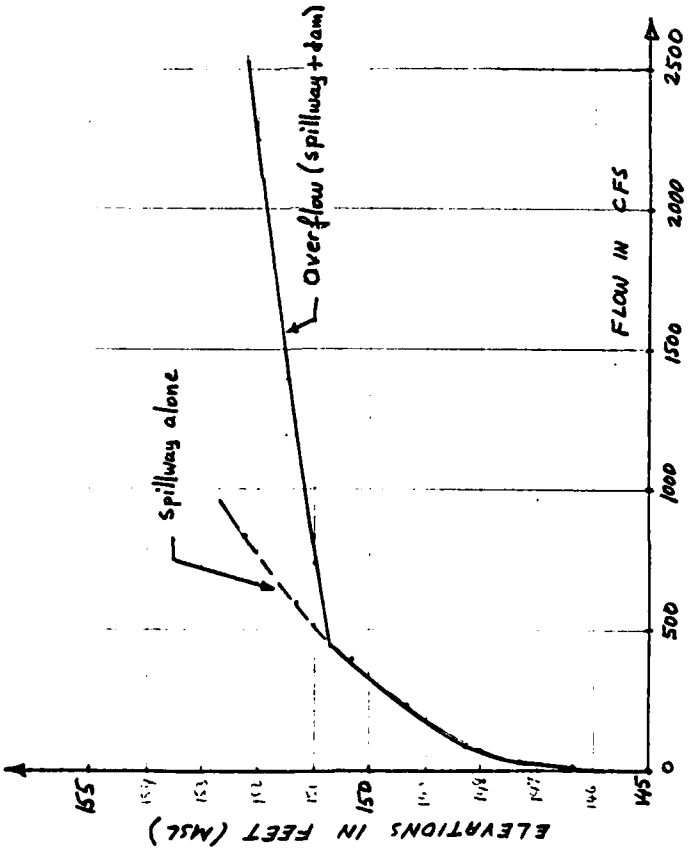
CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT H&A
PROJECT COE Dam Inspection
DETAIL North Reservoir Dam

JOB NO. 561-9-RT-10
DATE CHECKED 01/29/79
CHECKED BY AUG

PAGE 3
DATE 01/23/79
COMPUTED BY K.S. Chin

STAGE - DISCHARGE CURVE



CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass.

CLIENT H & A
PROJECT CDE DAM INSPECTION
DETAIL NORTH RESERVOIR

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PAGE 4
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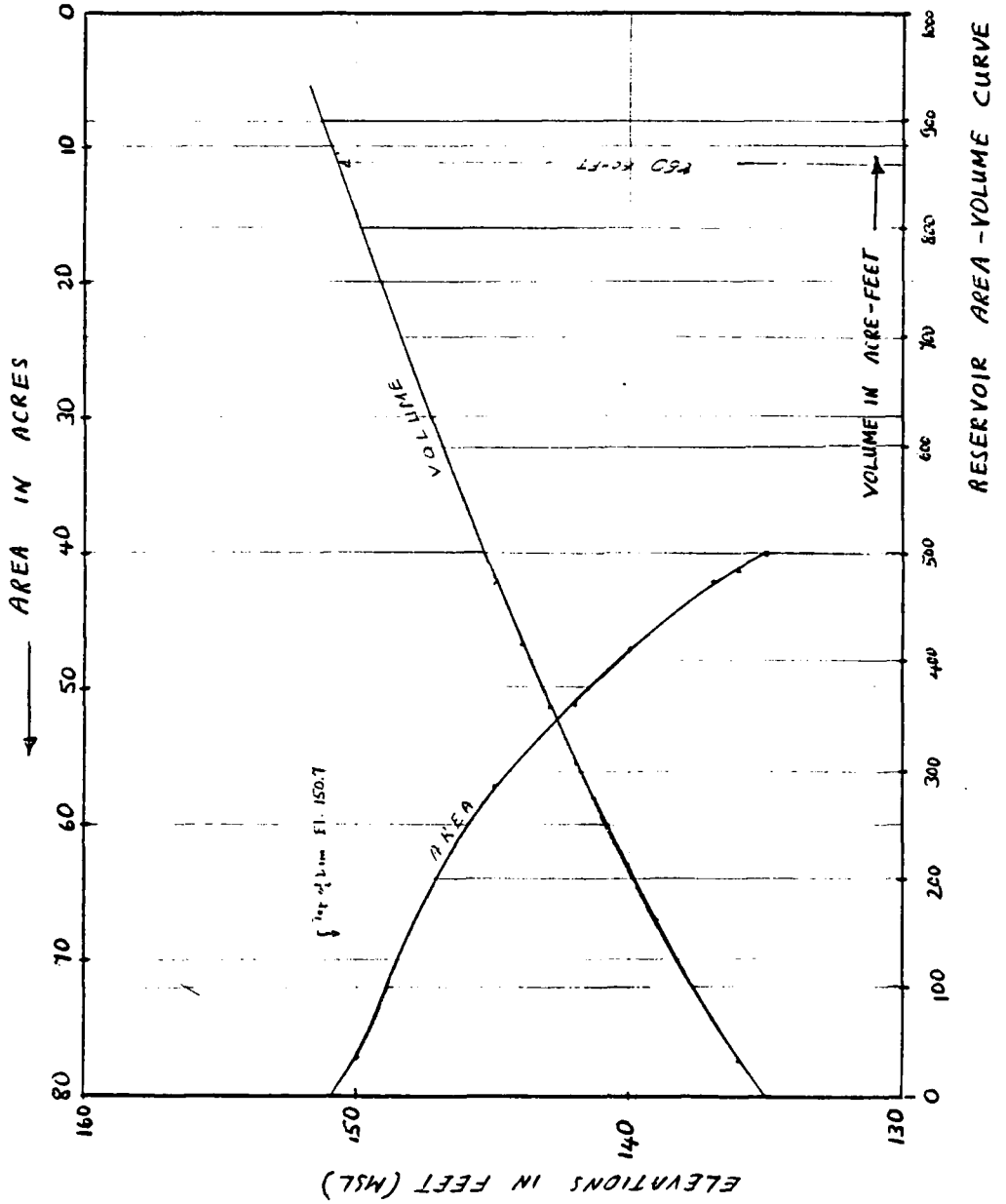
COMPUTED BY K.S. Chin



Dam Failure Analysis

$Q_{p_1} = \frac{8}{27} W_b \sqrt{g}\, y_o^{3/2}$ $\qquad W_b = 0.4\ L_m$

$L_m = 165$-ft (See section, P. D-6)

$W_b = 0.4 \cdot 165 = 66$-feet.

$Y_o = 27$-ft

$Q_{p_1} = \frac{8}{27} \cdot 66 \cdot 5.67 \cdot 140.3 \cong 15{,}600$ cfs.

Downstream Channel

The downstream channel may be studied in three sections:

(a) From the dam to junction with the spillway channel:

Here, the old Sawmill brook could carry the flow, but the existing water chlorination plant would probably be damaged.

(b) Sawmill Brook to Highland Avenue: the Brook channel disappears at a distance of about 100-feet upstream from the Highland avenue. This area with few residential units would be subject to severe flooding with possible loss of life.

(c) Around Highland Ave. & Forest St. to Aberjona River: Flood flows would hit fully developed residential areas with potential loss of lives and extensive property damage.

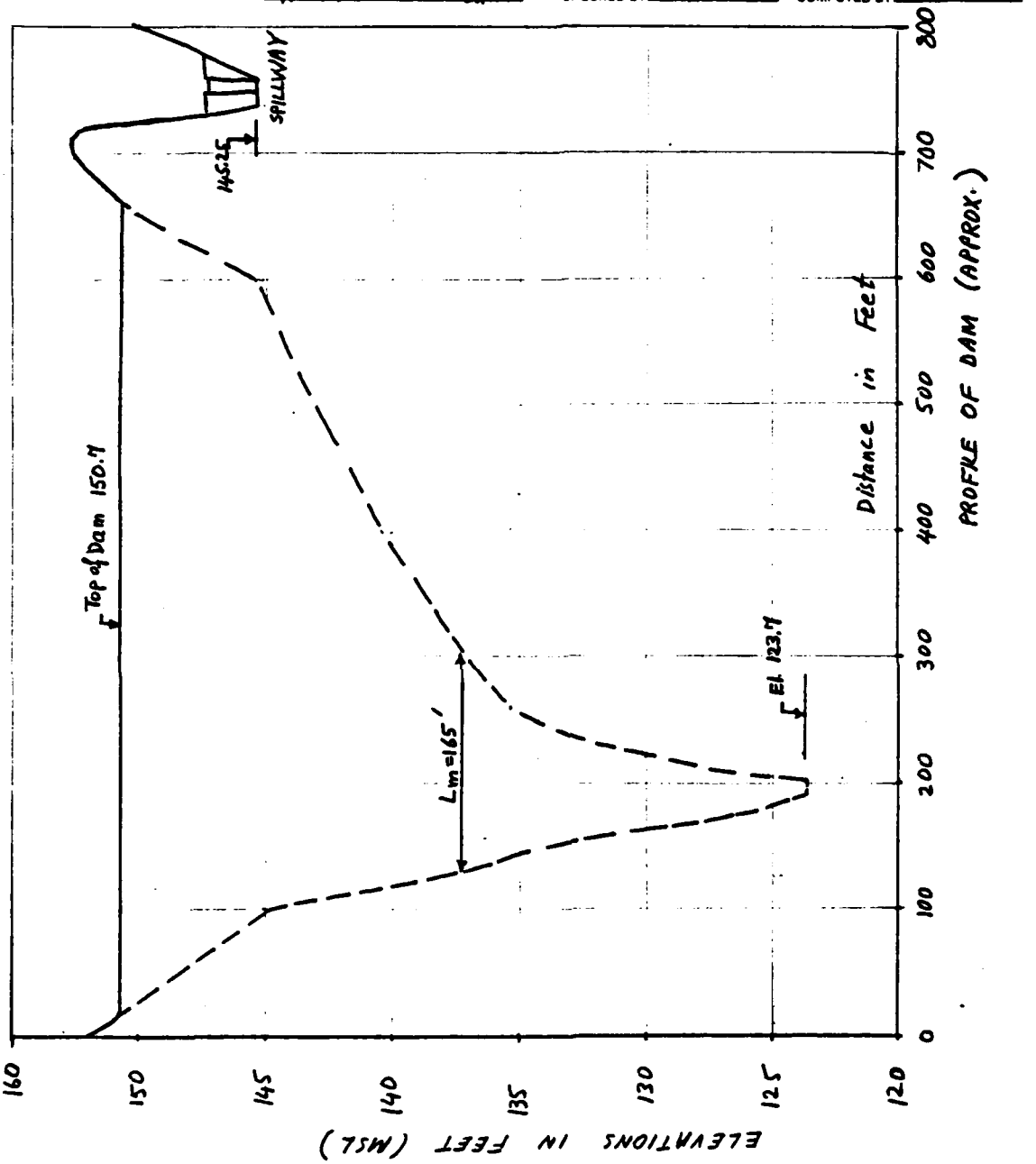
Conclusion: A dam failure would cause severe damages to several homes with potential loss of lives; streets and utilities would also be affected by the failure flood.

CAMP DRESSER & McKEE
Environmental Engineers
Boston, Mass

CLIENT H&A
PROJECT COE Dam Inspection
DETAIL North Reservoir Dam

JOB NO 561-9-Rt-10
DATE CHECKED 01/29/79
CHECKED BY AUG

PAGE 6
DATE 01/25/79
COMPUTED BY K.S. Chiu



APPENDIX E - INFORMATION AS CONTAINED IN THE NATIONAL INVENTORY OF DAMS

INVENTORY OF DAMS IN THE UNITED STATES

(1) STATE	(2) IDENTITY NUMBER	(3) DIVISION	(4) STATE	(5) COUNTY	(6) CONGR DIST.	(7) STATE	(8) COUNTY	(9) CONGR DIST.	(10) NAME	(16) LATITUDE (NORTH)	(17) LONGITUDE (WEST)	(18) REPORT DATE DAY | MO | YR
MA	457	NED	MA	017	07				NORTH RESERVOIR DAM	4227.4	7107.1	21FEB79

(11) POPULAR NAME	(14) NAME OF IMPOUNDMENT
	NORTH RESERVOIR

(15) REGION	(14) BASIN	(11) RIVER OR STREAM	(18) NEAREST DOWNSTREAM CITY–TOWN–VILLAGE	(19) DIST FROM DAM (MI.)	(20) POPULATION
01	06	SAWMILL BROOK	WINCHESTER	0	22672

(21) TYPE OF DAM	(22) YEAR COMPLETED	(23) PURPOSES	(24) STRUCTURAL HEIGHT (FT.)	(25) HYDRAULIC HEIGHT (FT.)	(26) IMPOUNDING CAPACITIES MAXIMUM (ACRE-FT.)	(27) IMPOUNDING CAPACITIES NORMAL (ACRE-FT.)
PGRECT	1874	S	29	27	860	500

DIST	OWN	FED R	PRV/FED	SCS A	VER/DATE
NED	N	N	N	N	07MAR79

(28) REMARKS
17-IN ABERJONA RIVER 24-APPROX

(29) D/S HAS	(30) SPILLWAY CREST LENGTH	(31) SPILLWAY TYPE	(32) SPILLWAY WIDTH (FT.)	(33) MAXIMUM DISCHARGE (FT.)	(34) VOLUME OF DAM (CY)	(35) POWER CAPACITY INSTALLED (MW)	(36) POWER CAPACITY PROPOSED (MW)	(37) NAVIGATION LOCKS NO.	(38) LENGTH (FT.)	(39) WIDTH (FT.)	(40) LENGTH (FT.)	(41) WIDTH (FT.)	(42) LENGTH (FT.)	(43) WIDTH (FT.)	(44) LENGTH (FT.)	(45) WIDTH (FT.)
1	200		19	450	43000											

(46) OWNER	(47) ENGINEERING BY	(48) CONSTRUCTION BY
TOWN OF WINCHESTER	WALTER H. SEARS	GEORGE H. NORMAN

(49) REGULATORY AGENCY			
DESIGN	CONSTRUCTION	OPERATION	MAINTENANCE
NONE	NONE	NONE	MA DPW

(52) INSPECTION BY	(54) INSPECTION DATE DAY | MO | YR	(55) AUTHORITY FOR INSPECTION
HALEY + ALDRICH, INC.	06DEC78	PUBLIC LAW 92-367

(56) REMARKS

END

FILMED

7-85

DTIC